THE HAWAIIAN
PLANTERS' RECORD

Some Observations on the Forest Problems of Hawaii.

By H. L. Lyon.

My studies of Hawaiian forests during the past year have greatly strengthened my conclusions as to the relation of the native flora to the soil conditions now existing in these Islands.

During the past summer I had the opportunity of visiting some of our forest areas in company with Dr. D. H. Campbell, of Stanford University, and he has expressed full agreement with my views on the matter, so I now re-state them with added confidence.

The ancestors of the plants which now constitute our native flora came to these Islands many, many years ago, when the soils were new. Their habits clearly show that they are adapted to recently-formed or well-drained soils, and require such soils in order to grow to best advantage. Now, had conditions remained favorable for continuous plant migrations to these Islands, there can be no doubt but that plants adapted to old soils would have also come in and established themselves as suited their needs. Plant migration was stopped, however, through the isolation of the Islands, and the plants which should and would naturally constitute our flora at the present time never reached here. Consequently, our present native flora is but the residue of a flora adapted to new soils, but lingering on in old soils because no plants of the proper type for these soils have come upon the scene.

To illustrate this point, I would offer the accompanying photographs, which fully substantiate my contention. They show Hawaiian forests coming and going.

Fig. 1 shows the conditions now existing on the Pahoehoe lava flow of 1880, a short distance above Hilo. This lava was a molten mass only forty years ago. Now it is so covered with vegetation as to make it appear like a planted forest of young trees when viewed from a distance. The vegetation is, however, all voluntary, and the remarkable thing about it is that its components are for the most part native species; there being a dearth of the introduced plants which have in-
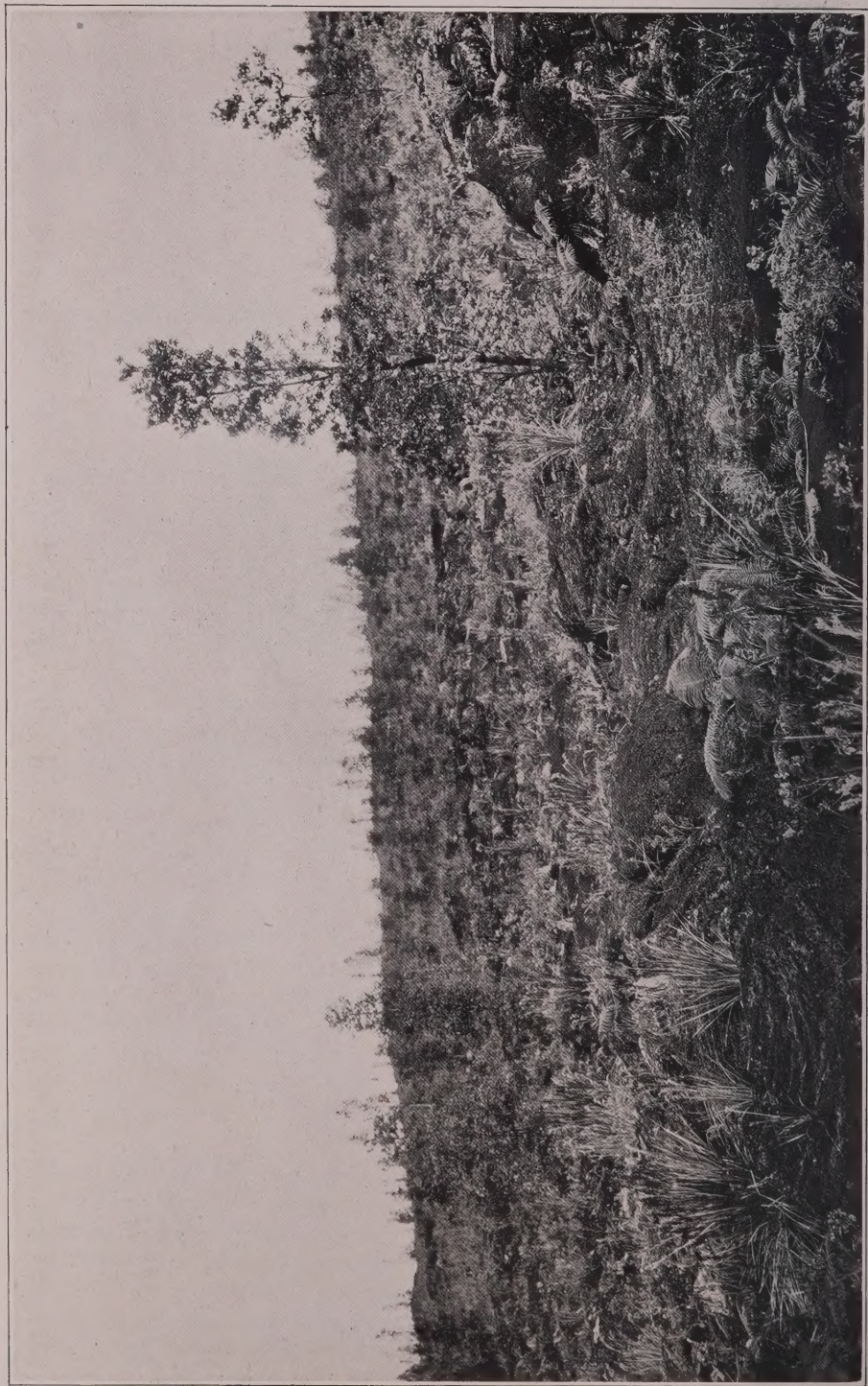
Fig. 1. Vegetation on 1880 lava flow.

vaded all open spaces on the old soils in the same neighborhood. The large trees are principally ohia, and some of them are over thirty feet tall. They are all very thrifty, and show every indication of enjoying perfect health.

Fig. 2 shows the northeast slope of Puulala, in the forest reserve near Waimea, Hawaii, at about 3000 feet elevation. This forest has been protected for many years, yet the native trees and ferns are dying out and disappearing, while the Hilo grass is pushing in and filling their places.

The native trees, shrubs and ferns very evidently delight in the conditions provided by new volcanic soils, such as the 1880 lava flow. They do not like old soils, however, and on such soils as that of Puulala, for instance, they become sensitive and fall into such a state of bad health that the slightest disturbance causes them to die. They are simply hanging on in the old soils of these Islands because no plants better suited to these conditions have appeared to crowd them out. If such plants had appeared in past centuries they would have easily replaced the present hangers-on, which cannot even withstand the progress of a vigorous grass which is adapted to growth on old soils.

Fig. 3 shows the condition existing over large areas of the watersheds of the Kohala Mountains above Waipio Cañon. All of the vegetation is in a conspicuously decrepit state, and it only needs slight interference to cause it all to die out. Hilo grass is rapidly invading this region, and undoubtedly it will soon furnish the necessary interference to change this landscape from a forest to an open grass-land.

The advocates of reforestation with the native trees often point to denuded areas where young ohia trees may be seen standing above the Hilo grass. A critical examination of such areas will invariably show that the young trees are perched upon old stumps, logs, etc., and not deeply rooted in the ground. These stumps and logs simulate the well-drained new-soil condition which the ohia requires; but it is only temporary, and, with the decay of these stumps and trees, the ohias will decline and eventually disappear.

Another factor which we should not lose sight of is the endemic insects and fungous diseases which are specific to the native plants.

A native tree, the "Olapa," shows evidence of more tenacity in our old soils than does the general run of native trees, but it is subject to the attack of a native borer, which kills many of its branches and renders the tree unsuitable for our purposes.

It is evident, therefore, that our native trees should not be employed separately or collectively for the reforestation of denuded areas, except on areas with well-drained subsoil.

Our Forest Problem Is Unique.

The primary object of all forest plantings on our watersheds must be to revive and create plant formations, including trees, shrubs, ferns and mosses, which will grow in a harmonious society and afford the greatest possible water-conserving capacity. No pure-culture forest can equal a mixed plant society in this respect.

Reforestation as commonly dealt with in text-books on forestry or as practiced by foresters in various parts of the world, aims at the creation of pure-
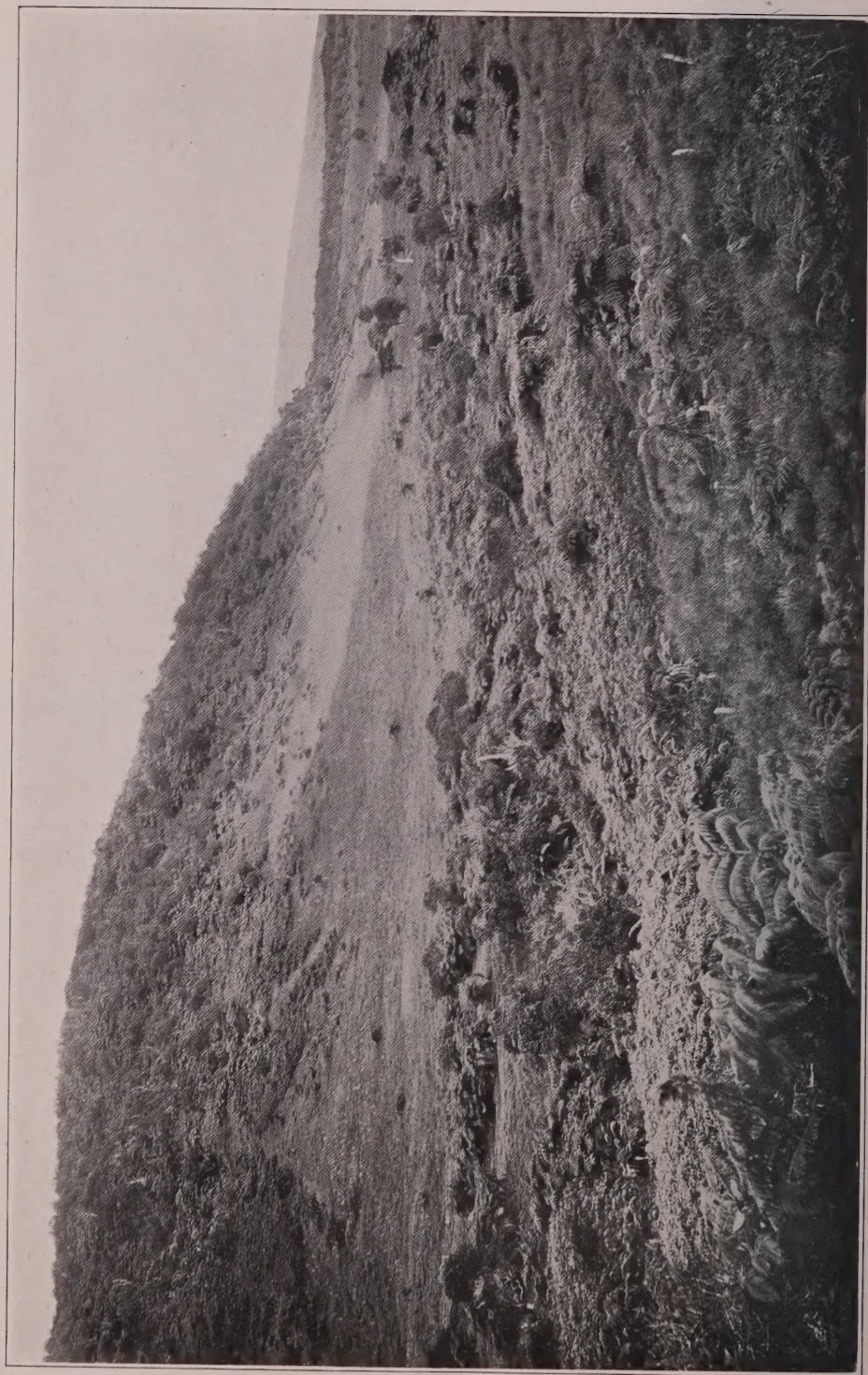
Fig. 2. Northeast slope of Puulala, near Waimea, Hawaii.

culture forests. Our reforestation problem is, therefore, unique; we have no precedent to go by. Ecological botanists have, however, supplied us with many careful analyses of such forest formations as we desire to create on our own watersheds. Our problem is to build similar forest-formations, using such material as is already available in the Islands and importing such additional material as is needed to round out our new plant societies.

Two Types of Plant Societies to be Created.

The forest-formations which we must create are of two general types: barrier-forests and deep or interior rain-forests.

I employ the term barrier-forest to include the plant formations which must constitute the outer exposed edge of our forests and form the transition from denuded areas to rain-forest.

We should first concern ourselves with these barrier-forests, for such forest-formations must be built up along the exposed edges of all the existing remnants of our native rain-forests if these remnants are to be preserved, and they must also be constructed along the margins of any area on which we would create a new rain-forest. It is then quite evident that the barrier-forest must be constructed first in any reforestation project we may undertake. It follows, therefore, that our first problem is to get together the proper components for a barrier-forest formation.

Experimental plantings looking toward the building of rain-forest formations can be started as soon as plants are available for the purpose. This work must progress more slowly than that in the barrier-forest formations and should be undertaken first on denuded areas where the native forest has nearly or quite disappeared.

Where Is Our Material to Come From?

Before we can begin to plant in our forests we must have something to plant. This material must come from local sources or from abroad.

We are seeking out all species of trees already established in these Islands, with a view to getting seeds and cuttings from them for trial in our forests. We are also making arrangements whereby we hope eventually to receive seeds from points scattered throughout the tropics and sub-tropics. This is now far more difficult than it would seem at first sight, for we must secure the services of an intelligent collector in each locality, and also provide for the expeditious transportation of the seeds after collection. This phase of the work will develop rapidly with improvement of transportation facilities and the relaxation of war restrictions.

Mr. Rock, of the College of Hawaii, is now in the Orient collecting seeds for our purposes.

Selection of Plants for Our Forests.

No plants will be given even a trial whose known habits and propensities make them undesirable denizens of our forests. Furthermore, only such plants will receive consideration as lend themselves to the formation of congenial plant

Fig. 3. Vegetation, mostly tree ferns, between Puulala and Waipio Valley, on Hawaii.

societies. Of the plants which seem to meet these requirements we will give preference to those showing the greatest adaptive abilities.

Viewing the forestry problem of our Islands as a whole, we find that our planting operations must eventually extend from near sea level (as on east Maui) to six and eight thousand feet elevation. We are also going to be asked to create forests under moisture conditions varying from 100 to 400 inches of rainfall per annum. Furthermore, our soils are going to present as wide a range of conditions as do either the local temperatures or rainfall. These and other less evident factors must be considered in selecting candidates for our forest plantings.

The plants offering the greatest promise are those which, in their native land, show an ability to adapt themselves to a wide range of conditions. If they occur naturally in restricted districts only, there is little hope of their thriving in any part of our forests, but if they grow through a wide range in altitudes, and hence in temperature and moisture conditions, there is considerable chance that they can adapt themselves to conditions existing in some part, at least, of our forest area. For example, take the Kohala forest area at 2000 feet elevation. If we choose trees for this project that occur only at 2000 feet elevation, say, in India, the chances are that they will fail to grow, but if we select species that range from sea level to 5000 feet elevation in India, our prospects of success are reasonably good.

The first qualification of all plants selected for forest planting must be ability to grow under the existing conditions, and under these conditions they must be vigorous growers, so that they can successfully compete with the Hilo grass.

We cannot hope to rebuild our rain-forests by planting out each individual tree, shrub and vine that enters into that forest. This would be an endless and hopeless task. We must find some good trees, shrubs, etc., that will work together as a proper forest cover, and, at the same time, spread their species to new areas through the production of seed. There seems to be a strong prejudice against any tree, shrub or vine that spreads naturally under existing conditions. This is the wrong attitude entirely, for we should really give little consideration to the trees, vines and shrubs that will not spread naturally under existing conditions of soil and climate. To be sure, we must avoid the introduction of obnoxious plants of the nature of Lantana, Klu, Thimble-berry, etc. No one can dispute the fact that the guava is a beneficial shrub and tree in these Islands. What we really need are more trees of equal vigor but adapted to growth at higher elevations.

We must bring these trees together on our watersheds, pit them against each other, and they will work out their own salvation by eventually resolving themselves into a balanced society, which will give us the complete forest cover on our watersheds that we now desire to create.

There are a few introduced trees and shrubs already present in these Islands which grow well under existing conditions at elevations of 1000 to 3000 feet, and, at the same time, possess some ability to spread spontaneously. These include the Karaka, Loquat and Japanese plum. These will undoubtedly prove useful components in our future forests. What we need are trees which grow to greater stature and have equal or greater abilities to spread.

Fig. 4. A beautiful banyan tree, a species of Ficus, growing at Kukuihaele, Hawaii.

There is one genus of plants with endemic forms in all parts of the tropics and sub-tropics, and represented by some 600 species, which offers the greatest promise of supplying us with just the trees we need to form the backbone of our new forests. This is the genus Ficus, which includes forms ranging from tiny vines to the most bulky trees in the world. The small, creeping fig on our stone walls, the edible fig in our gardens, and the banyans (Fig. 4) on our lawns and in our parks are all species of this remarkable genus. As imported trees they do exceptionally well under the soil and climatic conditions of Hawaii. The remarkable thing about it is that they never succeeded in reaching these Islands as natural immigrants. There are several very fine endemic species in the forests of Fiji.

In their native haunts all species of Ficus spread by seed which is produced in fruits more or less attractive to fruit-eating birds. These birds act as agents for the dissemination of the seed.

Now, the Ficus trees in Hawaii do not produce viable seed, and for a very good reason. All of these trees produce their flowers on the inside of a fleshy pocket which later becomes the pulpy body which we call the fruit or fig. Before these flowers can produce seed they must be pollinated, and the pollen must be transferred by some organism that enters and moves about in the pocket. In their native haunts there is a special insect that lives upon each kind of Ficus and attends to the pollination of its flowers. None of these insects have reached Hawaii, and, consequently, our introduced Ficus trees do not produce seed.

Ficus seeds are very small, and it is a relatively easy matter to get seed from countries where these trees are native, so we can easily secure thousands of seedlings. We are now endeavoring to secure this seed in quantity.

Most species of Ficus grow readily from cuttings, and we are using this means to propagate some of the species already present in the Islands.

The Ficus trees recommend themselves because of their rapid growth, sturdy habits, and seeming indifference to any disturbance or injury of their branches and roots. You could run cattle in a Ficus forest without endangering the lives of the trees.

They are wonderful soil-binders, their massive interlacing roots effectually preventing any washing of the soil beneath them.

Of the several species of Ficus now available in Hawaii, we would give preference to the true Caoutchouc, or India-rubber tree, Ficus elastica. In its native country it reaches a height of 200 feet, with a crown 150 to 200 feet in diameter. This crown is not so dense but that ample light gets through to supply the needs of undergrowth.

Ficus elastica has already demonstrated its ability to grow under existing conditions in these Islands. There are many trees in Honolulu. The huge tree in front of the Hilo Hotel is well known and has been admired by most residents of these Islands. In the grounds around the manager's residence at Kukuihaele there are fifteen splendid specimens; four of these are shown in Figs. 5 and 6. There are also two fine trees along Mud Lane, one of these being above 2300 feet elevation. In the Himalaya mountains this species ascends to 5000 feet elevation.

What better could we ask for than this magnificent tree with which to build the core of our new forests? It has every character that we could wish for. It
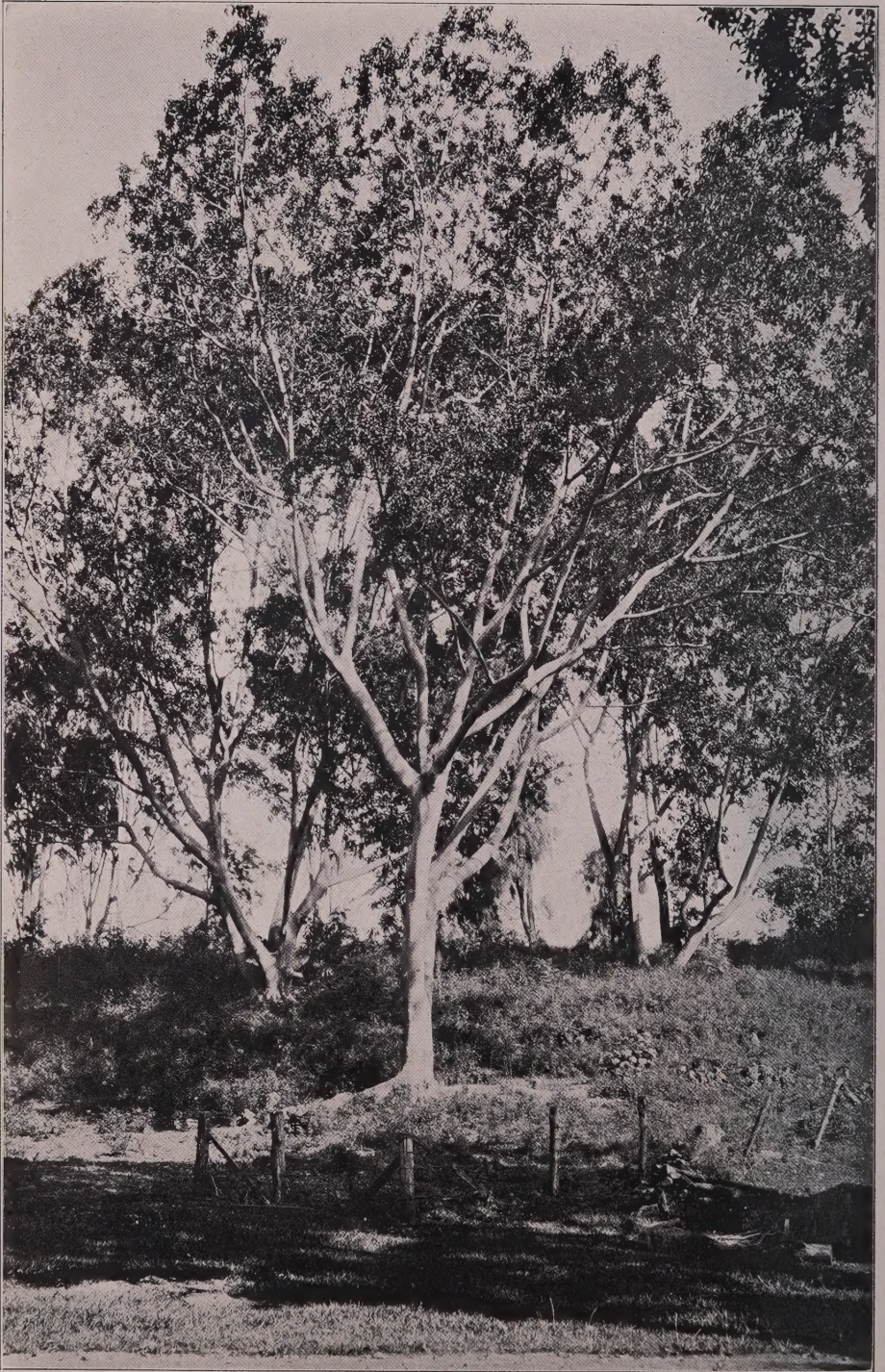
Fig. 5. Ficus elastica is an imported tree that has demonstrated its ability to grow under conditions existing in these Islands. These specimens are growing at Kukuihaele, Hawaii.

Fig. 6. A fine specimen of Ficus elastica growing at the manager's residence at Kukuihaele, Hawaii. This tree is over ninety feet tall.

will give vertical depth to our forests; it will permit undergrowth to grow right up to its very bole; it will prevent soil erosion, and it is quite free from the attack of insect pests or fungous diseases.

This tree has for many years been cultivated on a large scale in both India and Java, for the fine quality of india rubber which it yields. Hawaiian forests of this tree might eventually be made to yield heavy revenues without seriously impairing their water-conserving value.

Forests of the Kohala Mountains.

The forests of the Kohala mountains are degenerating at a rapid rate, and the water supply obtained from these mountains is more seriously threatened than anyone would suppose who has not investigated the matter. I have not had the time to make such a thorough study of the problems involved as would permit me to present at this time a comprehensive plan for rebuilding the forests of this region, but I have such a plan in process of elaboration. This will call for a second forest unit above Kukuihaele, to be handled along the same lines as those laid down for the Halawa-Niulii unit. Eventually the work in these two units should be extended to cope with the problems of the entire Kohala mountains.

The Watersheds of Oahu.

Probably no watersheds in these Islands are in a more critical condition than those on Oahu, and certainly no water supply is of more vital importance to this Territory than that derived from these watersheds.

This island has been more extensively and intensively exploited than any other island in the group, and, carrying as it does the bulk of the Territory's population, its forests have been subject to more interference from man and animals than those of the other islands.

Cattle have been the greatest factor in pushing the forests back to their present narrow limits, and at certain vital points cattle are still allowed to penetrate the remaining forests.

Where the cattle have been excluded the Hilo grass is keeping up a relentless attack, and little by little is pushing the forest line back towards the summits of the mountains.

A very serious injury has been done to these forests by the promiscuous cutting of trails. These trails have formed avenues for the entrance of Hilo grass, which, at many points well within the forest, has taken possession of considerable areas. This is very noticeable around the crater at the head of Palolo Valley. Ten years ago this trail ran beneath large trees and was bordered by masses of delicate ferns. Now the trees are dead and for the most part fallen over; the delicate ferns have disappeared and the ground is completely covered with Hilo grass.

If we make a careful estimate of the amount of water actually used on the Island of Oahu during any period of time, and then make a careful estimate of the maximum amount of water available on Oahu during the same period, we shall find that the two amounts are practically the same.

Now, the demands on the local water supply are going to increase rather than decrease, but the available supply is most certainly going to decrease if the denudation of our watersheds is allowed to continue at the present rate. Oahu will suffer from periodic water-famine, which will become more and more frequent until eventually drought will be her permanent and chronic condition.

Report on Diffusion. *

By A. FRIES.

The high state of efficiency in a modern milling plant is in some way due to the fact that methods have been adopted which approach those of the diffusion process; the disintegrating of the cane before crushing and the more liberal application of maceration water are instances. Together with improvements in the rollers, they have made possible a recovery of sugar in the mixed juice not equaled by diffusion.

Naturally all these changes are extended over a period of many years, and they brought along difficulties in the boiling-house and fire-room similar to those of diffusion, but they were also gradually met and overcome. It is therefore reasonable to suppose that diffusion installed at the present time could profitably apply all the improvements made and thereby overcome some of the serious problems that presented themselves in former years.

Col. Z. S. Spalding, who first introduced diffusion in the Islands, and whose plant operated very successfully for many years at Kealia, Kauai, says: "Diffusion was given up on account of the inability to dry the exhausted cane chips enough to burn in our furnaces of that time, without extra and expensive fuel. Today our furnaces would burn them freely and economically."

Equally interested and prominent in the enterprise of 30 years ago was Mr. J. N. S. Williams, whose concise and clear conception of the proposition as it presents itself today is of special value and interest. Mr. Williams says:

"Diffusion at the present day is a very different proposition to what it was 30 years ago. The largest single battery built at that time was to treat 400 tons of cane per day (24 hours). Now, no one would consider handling less than 1000 tons of cane in that time.

"Several small batteries can, of course, be used, but there the elements of first cost, labor in operation and current expenses must be considered. If diffusion is now to be considered seriously, we must look at the gain in the profit and loss account to be obtained, and as diffusion has nothing on milling as far as extraction is concerned, the gain must be made in operating expenses and reduction of losses in manufacture, notably in final molasses.

"If several small batteries are to be used instead of one big milling plant, it is doubtful if the operating expenses will be much reduced, as while the batteries do not cost much to maintain, the cane cutters are quite expensive. If shredded cane can be used in diffusion this may solve the problem of preparing cane for such work, but it has not yet been proved that shredded cane tightly packed will allow of efficient circulation, nor has it yet been proven that diffusion juice from shredded cane would be any more pure than mixed juice from mills, in which the cane has been prepared by shredding. The shredder disintegrates the cane to such an extent that all the soluble solids will be extracted by the diffusion process. It is therefore clearly apparent that there are several points to be cleared up definitely before diffusion will again become a live issue.

"No one will discard a good milling plant unless he can replace it by ma-

chinery very considerably its superior in operation and in cost, and while I am sure that the method of diffusion is the most simple for the extraction of sugar from the cane, I am also sure that to meet modern demands the batteries and equipment of 30 years ago will not serve, and considerable experimenting will require to be undertaken to demonstrate the efficacy of more modern equipment to be used with that process."

A communication from Egypt, where diffusion and milling are operated side by side at this time, was received by Dr. Norris.

LETTER FROM MR. H. NAUS, DIRECTOR-GENERAL SOCIETE DES SUCRERIES ET DE LA RAFFINERIE D'EGYPTE.

"In answer to your letter of February 27th, I have the honor to inform you that we have still three systems of juice extraction:

(a) Cane diffusion.
(b) Bagasse diffusion.
(c) Milling.

"Cane diffusion was, in fact, an enormous progress compared with all other proceedings at the time, if we think that it was working at full satisfaction 23 years ago.

"Since, bagasse diffusion has been introduced and milling perfected so that the day is not far off where cane diffusion may be given up. It would take a volume to give a full and clear appreciation about each system, but we may say, in general lines, that the results with a cane of 12.5-13.5% sugar and about 11% cellulose are as follows:

"1. Losses % cane:
Cane diffusion—0.35 to 0.45%.
Bagasse diffusion—0.20 to 0.35%.
Milling, crushers and 4 mills, 20% imbibition—0.45 to 0.65%.

"2. In proportion to the purity of the juice contained in the cane, the purity of the total raw juice, industrially extracted, is the highest with the bagasse diffusion. Then follows cane diffusion and the milling process, which does not comport appreciable differences, with perhaps a slight, but very slight, difference in favor of diffusion a little higher. None of the three is excessive. Cane diffusion more expensive than bagasse diffusion and bagasse diffusion and milling.

"It is my intention to stop a few days at Hawaii on my voyage to America in 1920. I shall be glad to expose then in detail all economical and technical informations on the subject to the Hawaiian Sugar Planters' Association."

After reading Mr. Naus' letter on the three methods of extracting sugar from the cane, viz., Cane Diffusion, Bagasse Diffusion and Milling, and considering that the data presented give the results of actual experience, one feels as if further argument in favor of diffusion were futile or should at least be postponed until more information from the Egypt factories is available. According to the figures, the extraction for cane diffusion is 96.92%; for bagasse diffusion, 97.88%, and for milling, 95.77%.

Without further knowledge of the machinery employed for slicing the cane, the treatment which the juices of the three systems receive before entering the evaporator, and the condition of the bagasse and its fuel value, the higher cost of

cane diffusion over both bagasse diffusion and milling cannot be explained. The main difficulties of the process in Hawaii were:

(1) The high cost of handling the cane and the expensive machinery for its preparation for the batteries.

(2) The necessity for extra fuel, brought about by the production of a bagasse not dry enough for burning and in too fine a condition for the furnaces of that time.

It was only through the introduction of the Searby shredder a few years ago that diffusion came in for some consideration again in Hawaii. The great capacity of the shredder and its successful operation so far, immediately makes it seem the proper machine for preparing the cane. It will materially cut down the operating expenses, but it will have to be demonstrated by practical tests whether the resultant material will be suitable for the diffusion process.

Assuming that the shredding is even, that there are no large pieces, will the cane thus disintegrated and dropped into the cells distribute itself evenly and allow a good circulation? The juice passing through the cells must come in contact evenly with all parts of the cane, there must be no hollow spaces or chance for the material to pack, or, in other words, the juices must freely and rapidly pass through the filled cells and the extraction must be equally good in all parts of the diffuser. Whether the shredded cane will fulfill these conditions has to be left to a practical test.

The drying of the exhausted chips and the burning of this rather powdery material presented another serious problem of the diffusion of former years, but with the present improvements in mills, furnaces and boiler-house equipment, the shredded cane, after being exhausted in the diffusion, and after having passed the improved mill with juice grooves, should be as efficiently burned as is the bagasse of today, and probably with less additional fuel, as much of the heavy machinery could be dispensed with.

It is possible that the above-mentioned difficulties are important factors in the higher cost of diffusion mentioned in Mr. Naus' letter. The shredder, Messchaert grooves and improved furnaces seem to offer a solution for these difficulties.

Besides the economy in power, diffusion has in its favor the saving of labor and material, as neither settling tanks nor mud-presses are necessary. The juice is clarified in the cells and after screening and heating can go directly to the evaporators. Following are a few figures representing the averages for a week's work at Makaweli in 1901 when diffusion was in operation:

Cane .... 4637 tons
Cane per hour... 34.5 "
Cane-juice:
    Brix 20.99
    Pol. 18.59
    Pur. 88.58

Diffusion-juice:

    Brix 17.83
    Pol. 15.43
    Pur. .:... 86.54
Extraction per 100 sucrose in cane...................... 97.0
Dilution 17.5%

Cane juice was obtained by pressing the chips in a hand press. Noticeable is the low dilution, and one would expect that with 30% dilution or more, and the finer material of the shredder, an extraction of 98% and over should be realized.

Report on Fire-Room Efficiency.*

By Alex. G. Budge.

Steam Pressures and Temperatures.

The subject of steam pressures and temperatures for a sugar factory is one which is open to a great deal of discussion, and in this paper the writer is only endeavoring to bring out certain considerations in connection with the subject, and give opinions which are personal and not based on any particular installation or experience in the operation of a sugar factory.

The ordinary pressures heretofore maintained in sugar factories have been limited to 125 lbs. and under. A great majority of factories are operating on pressures of approximately 100 lbs. per square inch. Pressures such as these are ordinarily called low pressures, as in contrast to any pressure above 125 lbs., which is ordinarily termed high pressure. The high-pressure steam is usually obtained from boilers capable of operating at 160 lbs. pressure. In ordinary power-plant practice, a pressure of 160 lbs. would be termed low pressure and pressures over 200 lbs. high pressure, which is an indication of the general practice and terminology throughout the country.

In a well-balanced sugar factory all of the exhaust steam is used in the evaporators and pans, so that when low-pressure steam is used on the engines there is no waste due to poor economy of engine operation with this low-pressure steam.

It is the general opinion that in a factory in which exhaust steam is blown to the atmosphere and live steam is taken from the boilers for boiling-house purposes, the control of the factory is very poor, and if properly checked up, this condition of waste exhaust could be eliminated. There is, at present, a tendency in factories to install turbine and electric drives, and it is apparent that this tendency is going to grow, with the probability that in the next ten years, electrification will take place in a great many of the sugar factories in these Islands. Where a turbine is used to drive a generator or shredder, the cost of the power in pounds of steam becomes an item of importance in the balance of the factory,

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due to the poor economy of steam turbines when operated with low-pressure steam, so that where turbines are installed, or are apt to be installed, the steam pressure available should be, for the most economical operation, 150 lbs. or higher. By operating with a high pressure, the cost per horse-power in pounds of steam at the turbine is reduced so that there is no danger of wasting the exhaust, which is very apt to be the case if the operating pressure is about 100 lbs. per square inch.

In factories where steam turbines are not installed, or where the engines operate on low-pressure steam, it has been noticed on several occasions that the work is much more difficult to perform than when pressures of 125 lbs. or higher are available. The experience of engineers who have installed high-pressure boilers and used this steam on their engines at 125 lbs. to 135 lbs. pressure has been such as to indicate far greater ease of operation and better economy as to fuel, due to the fact that at these pressures the power developed by the engine is sufficient to overcome any irregularities in the load on them which are the cause of trouble when operating at lower pressures. This high-pressure steam can be used on all the prime movers in the factory, and it is found that the operation throughout is generally more satisfactory.

A certain amount of live low-pressure steam at about 50 or 60 lbs. is required by many of the boiling-houses, and this can be obtained from the high-pressure boilers without loss in economy through a reducing valve. The reducing valve has the drawback of requiring a certain amount of attention, but, on the other hand, it favors the operation in that no loss of energy occurs by its use and the steam furnished to the boiling-house is dry and in some instances superheated; that is, the decrease in energy due to the drop in pressure is utilized in drying the steam, which reduces the amount of water to be handled by the traps and through the pans and evaporators.

The question of the advisability of superheat in a sugar factory is open to a great deal of argument, and unless there are turbines or engines, in connection with the factory, for the generation of power to be used for outside purposes, it is not considered advisable to install superheaters.

The use of superheated steam in power-generating plants is an admitted economy, but if superheated steam has to be used in a boiling-house in the evaporators and pans, it is probable that the evaporators and pans will not do as satisfactory work as with dry saturated steam, due to the poorer conductivity of superheated steam and the liability of getting the juices or syrups too hot.

It would seem advisable, therefore, to install so-called high-pressure boilers capable of operating at 160 lbs. pressure, which is a standard pressure, and to operate them at 135 or 140 lbs., using this steam on the engines and prime movers, securing the low-pressure steam required through a reducing valve on the boiling-house lines. This then gives an installation which will give the maximum economy as to prime movers, together with the most satisfactory operation, and permits of maintaining this pressure over an indefinite period of years, providing the boilers are given the proper supervision and care.

Report of Committee on Clarification and Filtration.*

By C. Budde.

As nothing new has developed in clarifying and filtering the raw cane juices during the past year, this report will, therefore, be only a recapitulation of the old systems which have been in practice in the different mills in Hawaii.

Liming: The lime used for clarifying purposes in Hawaii is mostly all made here from either coral rock or coral sand. Although not quite as good and pure as lime made elsewhere, its percentage of calcium oxide is sufficiently high, and percentage of silica and magnesia low enough to give satisfaction in clarifying our cane juices. Milk of lime at 15 Bé. is generally preferred, although dry lime is used in some mills.

As everything depends on a good clarification, great care should be taken that the juices should be limed to a point which will give the clearest juice and highest increase in purity. Liming the juice to neutrality is generally preferred by most men in charge, but very often alkaline or slightly acid gives better results, which, of course, depends on the variety of cane or soil and altitude of field it comes from.

Liming mostly takes place before heating of the juices. As far as I know, Maui Agricultural Company is the only place where the juices are limed after having passed through the heater, the advantage being that the heater tubes are free from scale at the end of the week. Mr. Foster reports that he never found any inversion, obtained a good clarification, and that the heater tubes remained free of scale at all times. By using Mr. Foster's method of liming the juices, there is the advantage gained of having a clean heater, but I believe there are possibilities of getting a heavier scale on the evaporator tubes.

Heating: The Deming system of heating juices is generally used here in Hawaii, and is so well known that it needs no further comment. As to the temperature of juices leaving the heater, 212° F. to 216° F. is generally accepted as safe, without running any risk of destroying sucrose or darkening the color of the juice. Some members who contributed to this report are of the opinion that even a temperature of 220° F. would be safe, as the time of exposure is very short, and the temperature drops back to 212° F. and lower as soon as the juices are discharged into the settling tanks, providing, however, the juice is not heavily over-limed.

On the other hand, Mr. Walker of Pioneer Mill Company and Mr. Biela of Kohala Sugar Company believe in a temperature below boiling point, as low as 180° F., the advantage being that, clarifying at as low a temperature as possible, is in reducing the decomposition of sucrose and preventing undue viscosity of syrups and molasses, and slow drying of massecuites. Mr. Walker states that he tried it for two weeks at 200° F. and at times at 190° F., and obtained a good clarification. The reason he did not continue at this temperature during the whole season was that he did not have sufficient evaporator capacity to take care of the

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* Presented at the Seventeenth Annual Meeting of the Hawaiian Chemists' Association.

colder juices. Next year, however, they will install a reheater that will do away with this trouble.

The following figures are the average result of 15 experiments of one hour duration each. Caledonia cane was ground while these tests were made, and the average temperature was 215° F. Slightly acid juice settled slowly, neutral and alkaline juice very much quicker. The increase in purity was highest in alkaline juice.

	Acid	Neutral	Alkaline
Purity Mixed Juice..........	82.72	83.00	83.4
Purity Clarified Juice........	83.80	84.7	85.6
Purity Increase............	1.08	1.7	2.2

Settling Tanks: There are various kinds of settling tanks in use in Hawaiian mills, and all are understood to be giving satisfaction. I believe if proper care is taken in liming, cars of old cane reported before they are unloaded, the temperature of juices kept up to a degree where it is known to give the best results, the biggest difficulty towards obtaining a good clarification and a high increase in purity is overcome, providing, however, there is capacity enough to give the juices sufficient time to settle.

At Honolulu Plantation we have twenty-two asbestos-covered inverted cone-bottom tanks; each has a capacity of 1000 gallons. Mud outlets are in the center, and the tanks can easily be emptied and washed out occasionally. Here I would like to mention that great care should be taken to keep all tanks, etc., as clean as possible in order to prevent inversion, as the juices handled on all clarifying and filtering stations are dilute, and subject to rapid fermentation. I have found hot water very useful.

The juice outlet is at the side of the tank just above the cone bottom. To this outlet inside the tank double elbows connect a three-inch copper pipe, supplied with a copper float. At the float end of the pipe there is a right-angle connection three inches long. This extends down into the juice below the scums, and as the double elbows are movable, the float descends with the level of the juice until the mud is struck. With fairly good and clean cane, about 90% is recovered as clarified juice. Pipes, floats and trough in front of tanks have all been made out of old Lillie evaporator tubes, and since their installation have not given any trouble whatsoever.

Sodium carbonate is used in a number of mills, but only for the purpose of obtaining a carbonate scale on evaporator tubes, which is easier removed than the harder sulphate scale. The amount per 1000 gallons runs from ½ lb. to 1 lb.

Double-screening of the juices is generally replacing sand and excelsior filters. Rotary, self-cleaning screens are being used in some mills, but mostly screens 3 ft. wide and from 6 to 8 ft. long are being installed and placed at an angle of about 30 deg. in order to allow the juice to keep the screen clean, by pushing the cush-cush ahead of itself. The mesh of the screens varies from 80-200, and wherever installed is reported to give satisfaction.

Resettling tanks are gradually being discarded here in Hawaii. They are still in use at Honolulu Plantation. The clear juice is drawn off in the same way as at the settling tanks, and about 40% is recovered as clarified juice. During this last season I ran without them for one month, but gave it up again, as my filter-press capacity is below standard and the amount of filter-press cloth used increased during that time.

To my question, "Where should the resettled and filter-press juice be returned?" those who answered agreed that it should be returned to mixed juice, as it is usually overlimed and might cause a heavier scale in evaporators, and also if there is not sufficient evaporator capacity, it falls upon the evaporator to raise the temperature of the filter-press juice to that of the clarified juice. In any case, piping should be so arranged to either return the juice to mixed juice tanks or evaporator supply tank.

Filter-press: As far as I know, plate and frame presses of different types are being used in the local mills. The size of the plates and thickness of frames have gradually been increased, and have reached a maximum of 34″ for plates and 4″ for frames at Maui Agricultural Company's mill at Paia.

At Honolulu Plantation we have eleven small presses and one large Catton & Neill press. How much more economical in time, labor, water and filter-press cloth a large press is than a small one can be seen by comparing the following data:

Size of Frames.	No. of Frames.	Filtering Area, Sq. Feet.	Mud Capacity, Tons.	Time of Filling.	Time of Sweetening Off.	Total Tons Mud per Press per Season.	Total Yards Cloth per Press per Season.	Yards Cloth per Ton Mud.	Cost Cloth per Ton Mud per Season.	Excess Expense of Cloth in Small Machine % Big Machine per Ton Mud.
24	36	275	0.525	4 hr.	4 hr.	336.86 7.48%	39c per yd. 365	1.083	$ .422	66.0%
34	44	706	1.25	2 hr.	3 hr.	798.56 17.73%	55c per yd. 368	0.462	.254	

In charging and sweetening off the presses the gravity system is considered very good practice, but pumps and montejus are still being used to a great extent.

The double filter-press system finds more followers right along, and although it requires more labor, as the mud has to be handled twice, it is considered more nearly fool-proof in getting the sucrose out of the cake.

Hydraulic closing devices should be installed wherever possible. An even pressure can be put on the presses with less labor and time, and the danger of breaking plates is reduced considerably.

Now and then it becomes necessary to employ other clarifying agents besides lime, such as Diamond P., Clarifos, Kieselguhr, etc., in order to get a good clarification or a lighter-colored juice. Towards the end of this season Waialua Agricultural Company had a run of exceptionally dark juices, from Rose Bam-

boo and D 1135 cane, which was very hard to clarify. Mr. Howard has been kind enough to make a report on this, which I herewith include.

At Kahuku, Mr. S. Peck is using a molasses carbon for clarifying and decolorizing the juices, and is turning out a very good quality of white sugar.

In connection with the bone-char filters at Honolulu Plantation, we use phosphoric acid and lime in clarifying the raw liquor (remelted raw sugar) and obtain a very clear liquid. This is very important, as the life of a char filter and per cent char used for decolorizing the liquor depend on it a great deal.

In conclusion, I wish to thank the members of the Hawaiian Chemists' Association for their contributions, and hope this paper will receive their approval.

Aiea, Oahu, T. H., September 17, 1919.

POINTS OBSERVED IN THE CLARIFICATION SYSTEM AT WAIALUA.

By L. W. Howard.

During the latter part of the crop of 1919 we experienced a great deal of trouble with juices that were very dirty and hard to clarify—mainly from Rose Bamboo and D 1135 canes. We did not have satisfactory results from merely overliming or underliming, or from a neutral condition.

We tried using the Diamond P clarifier, superphosphate of lime, and double superphosphate of lime, and found that it helped out, although our clarified juice was not then as clear and bright as good Caledonia or Lahaina cane juice. Our experiments, however, proved conclusively that we must *overlime* our juice, and precipitate the excess lime by means of phosphoric acid in some form. The amount of phosphoric acid to be used was necessarily large, owing to the fact that the mixed juice demanded a very heavy overliming.

We are always grinding several varieties of cane at the same time (the cane is unloaded from two sides at a time), and so we are going to rearrange our liming station in order that we can control the clarification of each scale (15,000 lbs.) of juice. With the rearrangement of our liming station and the installation of eight new settling tanks similar to the ones described in Mr. Renton's report last year, we believe that we shall have a very much improved clarified juice, although we shall no doubt be obliged to *overlime* our juice much of the time and use phosphoric acid in some form to bring the juice back to neutral or to a slight acidity.

Our set of excelsior filters was discarded toward the end of the 1919 crop, since we had found that our 200-mesh screen at the supply tank for the evaporator was retaining practically all that was being carried along with the juice from the settling tanks.

Our experiments have shown that the temperature of the juice passing through the heaters made no difference in the clarification of our juices, so we maintain a temperature of about 212.

We think that the smaller the amount of cush-cush one can have in his mixed juice (and have good filtering work at his presses), the better and easier will the work at the liming station be for all the juices, and especially for those from such canes as Rose Bamboo and D 1135, which we have great difficulty in handling.

Report of Committee on Evaporation and Boiling.*

By H. D. Beveridge.

The writer having been appointed Chairman of the Committee on Evaporation and Boiling, for the year 1919, reports as follows:

On July 1st I sent out an S. O. S. call to 45 different members of this Association, containing a list of general questions on the above subject, a copy of which follows:

Papaikou, June 30, 1919.

Dear Sir:—The writer having been appointed Committee on Evaporation and Boiling at the last Annual Convention of the Hawaiian Sugar Chemists, I would ask your assistance in preparing a paper, by answering the following questions:

1. What type of Evaporator, including Pre-Evaporator, do you consider the most efficient and economical for raw sugar-house work? Give reasons.
2. In terms of Tons of cane per hour, at 40 per cent dilution and 4 to 6 lbs. steam pressure, how many square feet of heating surface should an Evaporator contain, including Pre-Evaporator, to delived syrup at 70° Brix?
3. What do you consider the limit of concentration of Cane Juices to Syrup, as regards the making of good-grained Sugar? Give reasons.
4. Which of the methods of starting Molasses Syrup Strikes, to make a 96.5° Polarization Sugar, do you prefer?
    (a) Grain started from Syrup?
    (b) Grain started from Low-Grade Sugar?
    (c) Method of starting grain? Give reasons in each case.
5. Do you know of any method of boiling and curing Syrup Molasses Strikes of 94°-96° Brix, 76-78 App. Purity; Sugar, 96.0°-96.5° Polarization? To prevent such sugar from caking in the bags, when such Massecuite is cured hot, and the sugar bagged and piled without cooling off? Please describe in detail.
6. Please describe method of graining and boiling 2nd Massecuite Strikes. Also time of boiling, Brix, App. Purity of Finished Massecuite.
7. Give the number of days 2nd Massecuite requires to remain in the Crystallizers or Coolers before crystallization is completed.
8. Please give any data you may have covering the daily drop in Purity of Molasses from 2nd Massecuite, from the time Massecuite leaves the vacuum pan until crystallization is practically completed.
9. What disposal do you make of Second Sugar? Give reasons.
10. Do you make Second Sugar and Final Molasses, or 3rd Massecuite? What disposal do you make of your Third Sugars?
11. Do you have any trouble with 2nd or 3rd Massecuite swelling or foaming in Crystallizers or Tanks? Please give the cause and its prevention.
12. Please describe anything new or of interest on the above subjects to the members of the Association.

An early reply would be appreciated. Thanking you for your co-operation, I remain,

Yours truly,
(Signed) H. D. Beveridge,
Papaikou, Hawaii.

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* Presented at the Seventeenth Annual Meeting of the Hawaiian Chemists' Association.

I received a reply from 15 members.

QUESTION 1. *What type of evaporator, including pre-evaporator, do you consider the most efficient and economical for raw sugar-house work? Give reasons.*

The majority of answers to this question were in favor of the Standard vertical submerged type of evaporator, on account of its lower cost, simplicity and accessibility for repairs, ease of operation and keeping clean. Mr. J. W. Donald notes that the film type of evaporator with forced circulation has the highest place in efficiency, but prefers the Standard type for the above reasons. Mr. J. P. Foster prefers the Kestner for pre-evaporator, for the reason that steam of 40 to 50 pounds pressure can be used with safety, and vapors of high pressure can be removed for use elsewhere. Mr. H. S. Walker believes an evaporator having a large enough first body to take the place of a pre-evaporator would be a good arrangement.

The writer has only had experience with the Standard type of vertical submerged tube evaportor, but believes it the best for all-around work. At Papaikou we have a pre-evaporator of four cells that can be used separately or as one unit. This has approximately 1000 square feet of heating surface per cell, or 4000 square feet in all, one body of which is idle; one second effect of 12,000 square feet heating surface, which gives a total heating surface in pre-evaporator and quadruple effect of 15,000 square feet for the 1919 crop. There was evaporated from juices exclusive of wash water from presses, of which we have no authentic data, 5.2 pounds of water per square foot heating surface per hour, besides heating mixed juices to 215-220° F. These evaporators are all automatically controlled, so that little variation of the level of liquors in the different bodies occurs, which the writer believes to be an important factor.

QUESTION 2: *In terms of tons of cane per hour, of 40% dilution and 4 to 6 pounds steam pressure, how many square feet of heating surface should an evaporator contain, including pre-evaporator, to deliver syrup at 70° Brix?*

Answer:—The summary of the answers to these questions was for a pre-evaporator 80-85 square feet per ton cane per hour; triple 240 square feet; quadruple 320 square feet. This the writer believes to be ample.

QUESTION 3: *What do you consider the limit of concentration of cane juices to syrup, as regards the making of good-grained sugar? Give reasons.*

Answer:—The answers to this question were various and ranged from 60° to 75° Brix.

Mr. R. C. Pitcairn believes the limit is that point where syrup can be grained quickest in the pan without the use of water. They carry their syrup at 74° Brix at Wailuku, also because it is economical. Mr. E. T. Westley believes up to 75° Brix the limit. Mr. G. F. Murray, Pepeekeo, believes 65° Brix the best. Mr. R. J. Richmond believes in 60° to 65° Brix, but if fuel is no item, 50° to 54° would make a better-grained sugar. Mr. W. Lougher thinks 60° to 64° Brix,

according to the grade of sugar desired. Mr. J. E. Biela does not hesitate to say that any high density within the safety limit of not crystallizing in the evaporator, will produce good-grained sugar by careful pan-work. Mr. H. S. Walker says 70° Brix; it will require more care and time in boiling, but it can be done. Mr. W. Ebeling says not over 65° Brix to make the grain of sugar acceptable to the refiners. Mr. H. Johnson says 65° Brix. With higher Brix the pan-men are apt to use too much water in their endeavor to make good-grain sugar. Mr. Donald believes around 60° Brix, as pumped from the evaporators, the most desirable. Mr. W. K. Orth believes with a high purity of syrup 70° Brix and slow boiling. With low-purity syrup, 65° Brix the limit. Mr. J. P. Foster says the limit of concentration is just below that point at which microscopic crystals will form in the tank when the syrup cools, also a low-purity syrup can be boiled heavier than a high-purity syrup. The writer believes that concentration in the multiple-effect evaporators to as high a density as is possible is very important, more particularly where fuel is scarce and auxiliary fuel has to be used. One degree Brix gained in the multiple-effect means a large saving of steam in the pans. The writer believes with careful pan-work, good-grain sugar can be made from syrup of 70° Brix or over without the addition of water in the pans and at a large saving of fuel and time.

QUESTION 4: *Which of the methods of starting molasses syrup strikes, to make a 96.5° polarization sugar, do you prefer?*

    (a) *Grain started from syrup?*
    (b) *Grain started from low-grade sugar?*
    (c) *Method of starting grain? Give reasons in each case.*

Answer:—Most of the answers to this question were in favor of seeding massecuite with low-grade sugar as the most economical, although a few preferred to grain from syrup on account of the liability of dark seed grain in low-grade sugars. We have practiced seeding with second sugars mixed with syrup for several years and regard it as a simple and economical way to dispose of part of the low-grade product. The low-grade sugar is dropped directly from the centrifugal baskets into a tank fitted with stirrers. It is there mixed with syrup to 90° Brix and pumped by a magma-pump directly to a mixer on the pan floor. The procedure at Papaikou is, if there is more syrup-sugar mixture than is needed for seed, a part is drawn into the pan and melted, and then the usual amount taken for seeding purposes. This hastens the pan-work.

QUESTION 5: *Do you know of any method of boiling and curing syrup molasses strikes of 94° to 96° Brix, 76° to 78° App. Purity; Sugar, 96.0° to 96.5° polarization? To prevent such sugar from caking in the bags, when such massecuite is cured hot, and the sugar bagged and piled without cooling off? Please describe in detail.*

Answer:—To this question all the answers were, No.

At Onomea, during the last season particularly, we have had a lot of trouble with sugar caking in bags. Our condition is as described in the question. The sugar going to the pile at 48° C. and never moved again until shipment. We

find on shipping that this sugar is caked hard, which makes it difficult to handle and is destructive to the bags. The members heard from were unanimously of the opinion that cooling was the only known remedy. Perhaps some other member may know of another way out of this problem.

QUESTION 6: *Please describe method of graining and boiling second massecuite strikes. Also time of boiling, Brix, apparent purity of finished massecuite.*

Answer:—Most of the methods here described were those we are all familiar with. Mr. Orth seeds his low-grade strikes with sugar-dust; this method would be interesting to hear about. There has been a great improvement in the final molasses of many plantations this year. This improvement is, without doubt, the result of better low-grade pan-work. When the equipment allows, two boilings should be sufficient to exhaust the molasses further than we have yet reached. Hence it is quite important that the second-grade pan-work should be carefully and intelligently conducted. We should strive to make a grain of sufficient size and evenness to build our first sugars on, and not too large, or else the molasses will not be properly exhausted. For that purpose low-grade pan capacity should be sufficient for the needs of the factory, as this work cannot be rushed and obtain good results.

QUESTIONG 7 AND 8: *Give the number of days second massecuite requires to remain in the crystallizer or coolers before crystallization is complete.*

Answers:—Most of the answers to this question were governed by the low-grade crystallizer capacity, but generally ranged from 8 to 10 days up to three weeks, according to the time taken to reach atmospheric temperature. Mr. Walker and Mr. Pitcairn have each contributed some valuable data covering this question in the shape of charts showing the daily drop in apparent purity of second massecuite, also daily drop in temperature. These charts are part of this report, and show good work. Mr. Pitcairn has contributed a paper on "Crystallizers;— Their Use," which contains a lot of useful information on this subject.

At Onomea during the 1919 crop we have been doing some work along the lines as indicated by the above questions. These results with charts and a few remarks constitute a paper by the writer.

QUESTION 9: *What disposal do you make of second sugar? Give reasons.*

Answer:—Where a few remelted their second sugar entirely to get rid of the dark seed grain, the majority used what they could for seed and remelted the remainder. This seems the more economical procedure.

QUESTION 10: *Do you make second sugar and final molasses, or third massecuite? What disposal do you make of your third sugars?*

Answer:—All that did not make second sugar and final molasses, remelted the third sugars.

QUESTION 11: *Do you have any trouble with second or third massecuite swelling or foaming in crystallizers or tanks? Please give the cause and its prevention.*

Answer:—Some members report no trouble from low-grade massecuite foaming in the containers: always allow room in the receiver for this. All agree that the cause is too high a pan temperature before striking, causing decomposition, and the remedy is to cool off the pan before dropping the strike.

QUESTION 12: *Please describe anything new or of interest on the above subjects to the members of the Association.*

Answer:—Mr. Orth notes that the seeding of low-grade massecuites boiled to string proof with sugar dust shortly before dropping the strike makes for the better desugarization of low-grade massecuite. It would be very interesting to hear from Mr. Orth on this subject. Mr. Westley notes that during the last season at Paauhau they have remelted and returned all low-grade sugars to the mixed juices. Boiled their second and third massecuites from higher purity and raised the Brix of the third massecuite from 93° to 95°. This method has given them a better purging massecuite and lower waste molasses than ever before.

Mr. H. L. White, chemist at Onomea Sugar Co., has a paper on low-grade pan-work which contains valuable information on this subject.

I believe some of the plantations are changing their coil-vacuum pans to calandria pans. It would be interesting to hear from those gentlemen on this subject as to why they are making such changes. At Onomea, 1918, we installed a 25-ton calandria pan which has given excellent satisfaction this last year. We have been able to increase the quality of our sugar from 29% small and very small grain for 1918 crop, to an average for 1919 crop of 10% small and very small, besides making 2100 tons of sugar more than 1918 in the same number of days.

RESULT OF SOME SECOND MASSECUITE EXPERIMENTS AT ONOMEA.

By H. D. BEVERIDGE.

At Onomea during the 1919 crop we carried on a series of experiments on second massecuites for the purpose of definitely determining the length of time such massecuites required to remain in motion before crystallization was practically completed. Also, to determine the daily drop in temperatures as compared with the purity of molasses drained off. In conjunction with these experiments we wished to ascertain if there was any loss of sucrose in the crystallizers due to decomposition or other causes. The averages of these experiments are plotted on the blue-prints and charts accompanying this article, but I will give average analysis of the eight crystallizers as struck and when they were discharged:

	Brix.	Sucrose.	Gravity Purity.
Struck	96.60	52.99	54.86
Emptied	96.52	52.90	54.81

These strikes were boiled in a 650 cu. ft. calandria pan of 376 sq. ft. heating
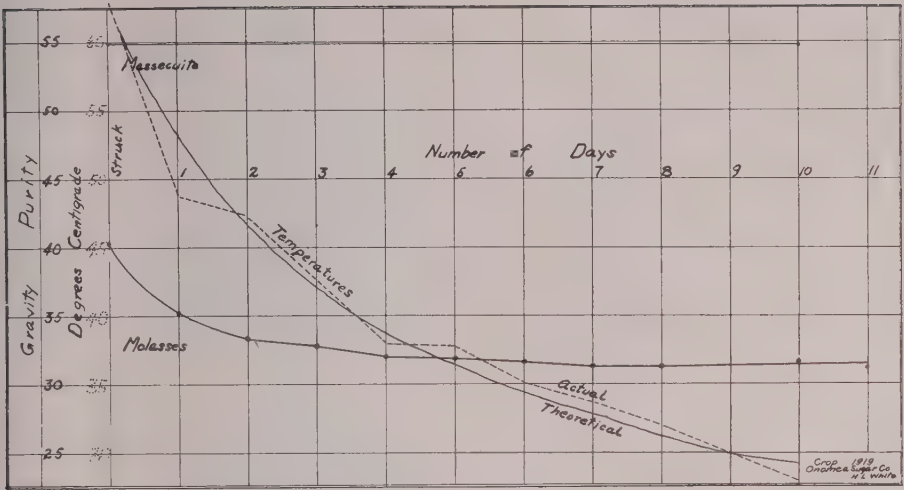
Temperature and Purity Drop in Crystallizers.—Onomea.
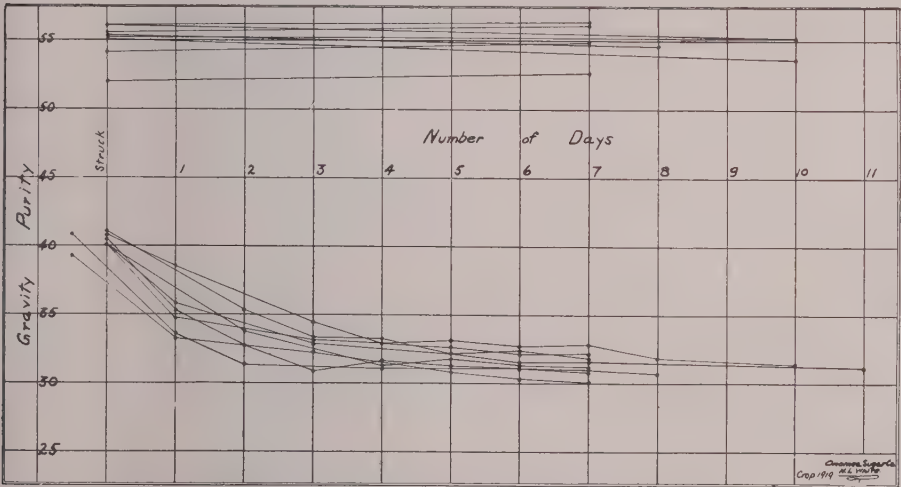
Massecuite and Molasses Purities.—Onomea.

surface. Exhaust steam 4 to 6 pounds gauge pressure; vacuum 27 inches; temperature 140° to 145° F. One strike and one cut to each crystallizer, or approximately 900 cu. ft. per crystallizer. Time of boiling one crystallizer, 24 to 28 hours. Crystallizers of the covered type without water jackets or any heating or cooling arrangement whatever.

The conclusions that can be drawn from these experiments point out that there is very little if any loss of sucrose in crystallizers whose massecuites are boiled at low temperatures. They also point out that practical desugarization of the massecuites occurs in the first four or five days after going to the crystallizers. With these experiments we began with 54.9 G. P. and 63° C. temperature of hot massecuite. Molasses drained off from the hot massecuite averaged

40.4 G. P. or a drop of 14.5 points in the pan, and after remaining five days in the crystallizers had reached 32.0 G. P. and 37° C. temperature. If you will notice on the chart, in these experiments where the two curved lines cross (allowing for an adjustment in the plotting) would be the point where the crystallization is practically complete. The total G. P. drop from strike to five days would be 22.8 points. As the waste molasses from this factory averages around 35 G. P. and the drop in purity for the next seven days is 0.5 of a degree, the question arises why carry a large stock of second massecuite at any time. A 50% less stock would mean less containers, greater accuracy in taking stock, and if there is any chance of loss by inversion, this change decreases and more sugar in the bags, where we all want it.
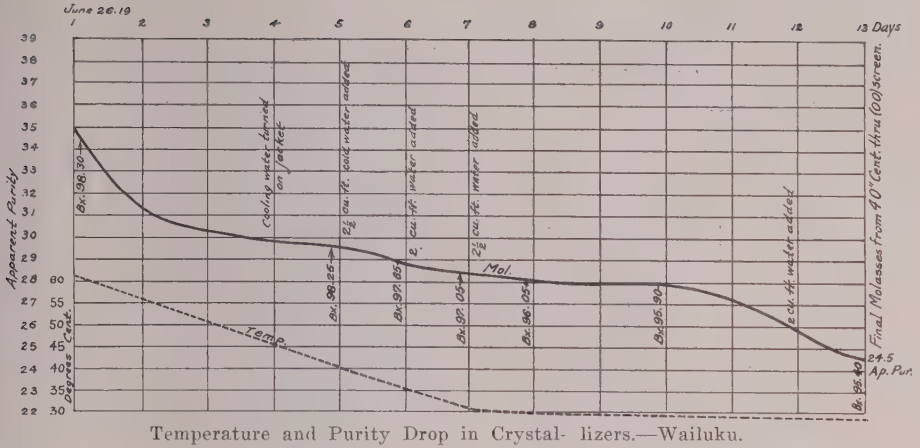
CRYSTALLIZERS—THEIR USE.

By R. L. PITCAIRN.

While it is undoubtedly true that a pan of low-grade massecuite boiled to a heavy density will, when put into a tank, crystallize some, it appears that the growth of the crystals takes place to a much more marked extent while the massecuite is in motion, or the crystals even sinking to the bottom by their own weight. An example of this is found by simply bringing a pan to the graining point and turning off the steam on the same. Immediately the crystals will appear in a great number and will continue to grow as long as the massecuite is even in slight motion, but after sufficient time has elapsed to allow the pan to quit simmering, the growth of the crystals will practically stop, and it is the coming into contact of the surface of the crystals with the immediate sugar in their own neighborhood that makes the crystals grow and exhausts the molasses, and if a low-grade pan has been boiled to a heavy density, the exhaustion nearly completed in the pan as it should be, it is simply a matter of using up the mother liquor between the crystals as far as possible, and, therefore, I believe this can best be accomplished by crystallization in motion.

Ordinarily, in a beet house 72 to 96 hours will exhaust the molasses in the crystallizers to a point where the crystals have practically stopped growing, and no further financial benefit can be derived. The massecuite will then have reached a temperature of 38 to 40 degrees centigrade; but if at this stage a barrel of water at about 26 to 32 degrees centigrade is added slowly, say one-half gallon an hour, the massecuite receives a new density and the crystals have a new area to work against and further crystallization occurs; also, the density of the massecuite having changed downwards, it purges more readily in the centrifugal machines and the amount of water to be added is governed by the density, the viscosity of the massecuite, the time at disposal, and the effect on the ultimate molasses purity.

Regarding temperature of massecuite while in motion, the temperature curve of the cooling massecuite resembles very much the expansion line of a good indicator card to where the exhaust begins to open. At the latter point it has gener-

Temperature and Purity Drop in Crystal- lizers.—Wailuku.

ally reached a temperature of 38 degrees centigrade in 72 to 96 hours. At this point water can be added direct. If there are water jackets on crystallizers, cold water can first be turned on the jackets and in twelve hours the massecuite will have dropped to about 32 degrees centigrade. During the later cooling stages the massecuite takes up very rapidly and is generally crying for water.

Regarding the temperature of the center of the massecuite being considerably warmer than the outer massecuite, I have found from repeated temperature readings that the reduction of the temperature is very uniform throughout, and 2 degrees centigrade difference is the most I have been able to trace. The speed of the crystallizers during numerous experiments was generally one revolution every two minutes.

Regarding benefits derived from outside tanks (unless the massecuite is in motion), I believe the benefit claimed for these tanks is due to the growth of the crystals while in motion, going out and coming in, and while the massecuite is settling, and that the tanks are in most cases an injury to the mill employing same, as in all tanks at rest the scum, water, gases and foreign matter come to the top and inversion takes place, and the top will show a strong acid reaction, increasing with the length of time at rest, especially in tropical climates; still another grave danger of massecuite at rest is the possibility of the formation of a new false grain that cannot be caught in the centrifugal machine. Also, they require time and labor to operate, and the massecuite, when brought back into the mill to purge, is viscous and does not purge as freely as when dropped from a crystallizer. These tanks also have a tendency to allow boiling-house operators to store an immense stock that should be in the bag in a well-balanced house, as it is axiomatic of the sugar industry that after the product enters the mill, the sooner it is in the bag, the more you will have; and I personally believe that twelve crystallizers for low-grade work will handle the product of a 1000-ton cane plant, as I know that eight crystallizers will handle a 600-ton beet sugar mill, providing intelligent use is made of them.

Ordinarily, in a 800 to a 1000-ton cane plant a crystallizer is filled every eighteen hours, and with twelve crystallizers the massecuite, even when running
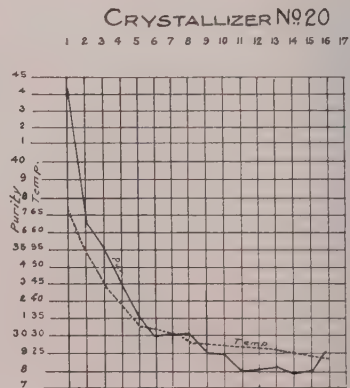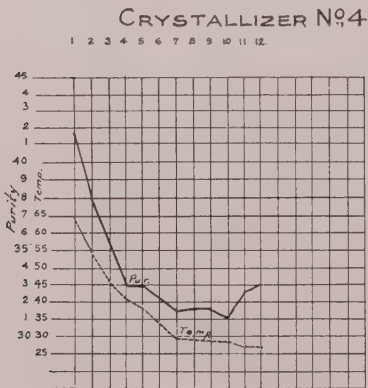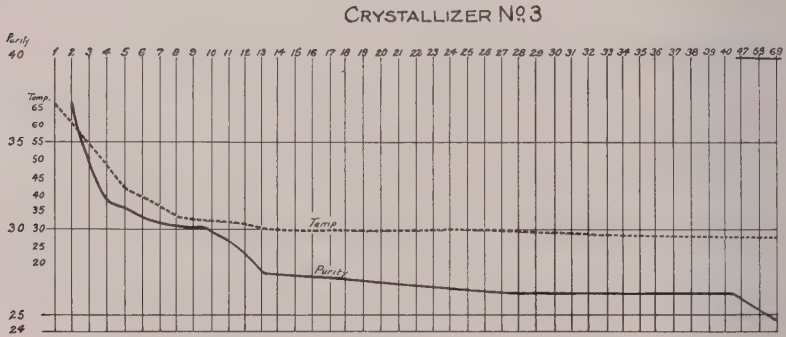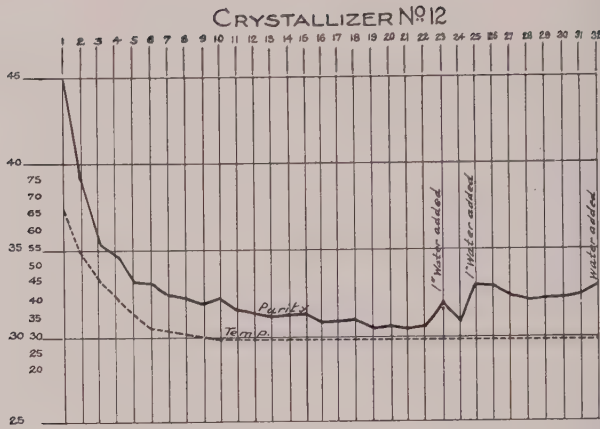
Temperatures and Molasses Purities.—Pioneer Mill Co.

heavily in quantity, will have at least eight days to be treated and allow the cooling without water jackets to 38 degrees centrigrade in the tropics by the sixth day, when water can be added directly but slowly and in a fine stream at the rate of half a gallon per hour. It is imperative that the crystallizer should not be flooded, for if this is done, due to the motion of the massecuite, some of the grain is remelted; but if added slowly and the crystallizer has been filled to only within twelve inches of the top, the water will be immediately absorbed by the massecuite, and the massecuite will soon free itself and lose the heavy gummy appearance that so often affects low-grade massecuite, especially if the original purity of the cane or beet has been low. Water can also be further used with beneficial results if it can be pumped into the massecuite slowly and the massecuite then kept in motion until it enters the centrifugal machines. Two per cent water can be added this way, and it will wonderfully increase the purging qualities of the massecuite, but the massecuite must be kept in motion. The rise in purity due to the water is very small indeed, unless heat is applied.

The work of handling cane or beet-sugar massecuite appears to be identical in all respects. In referring to crystallizers above, I am referring to the circular water jacket type. In no case have I found steam advantageous, and have always found the use of water better than molasses to add, as I believe it is impossible to keep putting low-grade products back through the house without losing sugar, and it also keeps in circulation products that should have been previously eliminated.

In Vol. 8, *Planters Record,* 1912, will be found the following by Dr. H. Claassen, in connection with his article on the crystallization of sugar in practice:

"The new models of boiling and crystallization apparatus are indeed installed in most factories, but in some cases these are simply used to incorporate as much syrup as possible with the crystals, so that the weight of the raw sugar is increased without regard to the quality. That such a procedure is scientifically contemptible and also mistaken from the commercial standpoint must be apparent to every practical man upon reflection."

SOME DATA CONCERNING LOW-GRADE PAN WORK.

By Henry L. White.

Among the many interesting problems that present themselves in a sugar factory, there are a number open for investigation on the subject of low-grade pan work. The following data are set forth to give some more light on the destruction of sucrose during boiling in the low-grade pan. The question was asked: "Does the sucrose molecule undergo any destruction during the period of boiling in the low-grade pan?" The only logical answer is a presentation of data collected on the subject. I will set forth these data and follow with any explanation or discussion which may be pertinent to a better understanding.

The first molasses was measured in a tank just before being drawn into the low-grade pan. Each drink had to be measured separately, as the arrangement

of tanks did not permit all the molasses to be measured as one volume. The temperature of each drink was recorded, but did not differ materially from the temperature of the massecuite at the time of striking, so any calculations concerning changes of volumes due to temperatures have been omitted. Carefully-taken samples of molasses were stored and the analysis of the entire sample was made at one time. From the Brix and the corresponding value in Table No. 3, Methods of Chemical Control, H. C. A., 1916, the weights of molasses and massecuite were determined. The massecuite from each strike was analyzed at the same time with the sample of molasses. All ash determinations were made in duplicate and agree within one-tenth of one per cent. In cases where the ash value of the molasses and the ash value of the massecuite do not correspond with the figured ash content from the Brix, the sample was analyzed again for ash and the resulting figure agreed, within the above limits, with the original determination. The acidity figure is only vaguely relative, as I do not believe the titration of molasses or any other dark-colored sugar-house product can be accurately controlled where phenolphthalein is the indicator. In fact, a number of titrations both in cane and beet-sugar work prompt me to draw this conclusion. I made an attempt to get another indicator, but it did not arrive in time to do his work, hence the acidity values are determined entirely by phenolphthalein as an indicator, and I do not consider them any more accurate than about 50% of the represented values. The figures on the acidity are a relative figure only.

TABLE NO. 1.

MOLASSES						MASSECUITE					
Tons	Brix	Sucrose	G. P.	Ash	Acidity	Tons	Brix	Sucrose	G. P.	Ash	Acidity
45.118	78.30	43.13	55.08	5.35	.1030	36.811	95.75	53.71	56.10	6.49	.0265
49.282	79.00	43.11	54.57	5.43	.1025	40.016	96.65	53.38	55.23	6.73	.0355
48.648	78.65	42.81	54.43	5.44	.1020	39.191	96.30	52.91	54.94	6.73	.0260
49.973	78.30	42.00	53.64	5.46	.0920	39.703	97.00	51.83	53.43	6.97	.0300
47.660	77.50	41.43	53.50	5.18	.1050	38.339	96.50	51.69	53.57	6.49	.0540

Table No. 2 is complied from Table No. 1, and gives the actual number of tons of solids, from the Brix; and the actual number of tons of sucrose from the Clerget sucrose figure. It was not hoped that the individual values entering and leaving the same pan would check, but it was thought that they would be relatively close. Errors in analysis of the samples and particularly errors in measuring the quantities would cause any of the discrepancies shown in the individual analysis. As may be seen, the average of the five molasses analyses agrees very closely with the average of the five massecuite analyses. The fact that the tons of sucrose going in and the tons of sucrose coming out agree so closely is not attributed to the accuracy of the work altogether, but more logically to a coincidence of figures.

TABLE NO. 2.

	Tons Molasses	Tons Brix	Tons Sucrose			Tons Massecuite	Tons Brix	Tons Sucrose
1	45.118	35.227	19.459		1	36.811	35.247	19.771
2	49.282	38.933	21.245		2	40.016	38.675	21.361
3	48.648	38.262	20.826		3	39.191	37.741	20.736
4	49.973	39.129	20.989		4	39.703	38.512	20.578
5	47.660	36.937	19.746		5	38.339	36.997	19.817
	Totals	188.588	102.265				187.172	102.263

From Table No. 2 the average purity of the molasses going in is:

$$\frac{102.265}{188.588} = 54.23\%,$$

and the average purity of the massecuite coming from the pan is:

$$\frac{102.263}{187.172} = 54.64\%,$$

which indicates a slight rise in purity due to the operation of boiling. Whether or not this is positively true can hardly be determined with so few experiments, especially as the rise lies well within the field of experimental error. On the other hand, had there been an appreciable loss in the pan work, the purity would have been lower coming out than going in, and this would throw the possibility of error out of the question, as the difference would exceed the allowable experimental error.

The logical conclusion, based on the above work, is that there is no appreciable loss of sucrose in the operation of the low-grade pan as long as the conditions of 140 to 145° F. and 26.5 inches of vacuum are maintained.

Should these conditions be changed materially, the whole phase of the experiment changes, and the above results could not apply. The following experiments will serve to show that there is a considerable loss under certain circumstances:

(1) One liter of sample No. 1 above was heated for 24 hours on a water-bath, at 190 to 205° F. (87.8 to 96.0° C), with a little water added. The color darkened and the odor of burning sugar was strong. The sample was cooled and the following analysis made:

Brix, 89.3; sucrose, 37.72; gravity purity, 42.24; ash, 6.11 and 6.08. Drop in purity, 13.86. Ash figured from sample No. 1, 6.05.

(2) One liter of sample No. 2 above was heated for 24 hours on a water-bath, at 165 to 172° F. (74.0 to 78.0° C), with a little water added. No marked change occurred as in the first experiment. The samples was cooled and the following analysis made:

Brix, 91.80; sucrose, 49.97; gravity purity, 54.43; ash, 6.44 and 6.41. Drop in purity, 0.80. Ash figured from sample No. 2, 6.40.

In closing it may be said that, while the data are not sufficient to draw any

definitely accurate conclusion, yet they point very strongly to the well-established idea that when the low-grade pan is kept at a temperature slightly below 150° F, there is no appreciable loss of sucrose during the operation of boiling.

ACIDITY AND INVERSION.

By R. C. PITCAIRN.

In beet sugar houses it is customary to keep a very rigid control over the acidity or alkalinity of the thick and thin juices and molasses throughout the process of manufacture, each house working to a very definite alkalinity at the various stations. For the purpose of comparing beet and cane practice in this respect I have tried to get figures representing the work of average cane factories, and with this in view obtained samples of second massecuite and final molasses from seven different mills—two from Maui, four from Hawaii and one from Oahu. These samples were titrated against N/28 NaOH, using Phenolphthalein, and acidity expressed as is common in beet houses as grams CaO per 100 grams sample.

An interesting fact brought out was the rather wide divergence in acidity of the different samples: the massecuites ranged from 0.200 to 0.550 (gm. CaO per 100 gm.) ; the molasses from 0.350 to 0.950.

The higher of these acidities would in beet work be considered decidedly dangerous. It is possible that the acids encountered in cane products are so weak as to have only a feeble inverting action, but even a neutral solution of sucrose decomposes somewhat on long heating and with any given acid inversion is proportional to concentration.

In an attempt to learn something of the inverting power of the acids in cane molasses under approximately factory conditions, I heated various samples of molasses and massecuites in a constant temperature oven at 65° C for periods up to 96 hours, determining the acidity and the gravity purity before and after heating. Following is a summary of the results obtained:

MOLASSES.

| No. | Before Heating | | Hours Heated | After Heating | | Loss |
	Acidity	Gravity Purity		Acidity	Gravity Purity	
1	.400	36.08	48	.400	35.51	0.57
2	.400	36.91	48	.400	35.10	1.81
3	.950	32.92	48	.950	31.92	1.00
4	.900	35.19	62	.900	32.98	2.21
4	Neutralized		62	.200	33.46	1.73
5	.600	34.06	62	.600	28.85	5.21
6	.650	35.21	48	.650	27.61	7.60
7	.350	36.99	48	.350	36.58	0.41
8	.400	33.82	56	.400	30.60	3.22
8	Neutralized		56	.100	32.73	1.09

MASSECUITES.

No.	Before Heating		Hours Heated	After Heating		Loss
	Acidity	Gravity Purity		Acidity	Gravity Purity	
1	.300	53.44	96	.350	52.69	0.75
2	.200	52.84	48	.200	51.93	0.91
3	.350	56.75	42	.350	52.60	4.15
3	Neutralized		42	.090	56.88	—0.13
4	.550	54.34	42	.550	49.42	4.92
4	Neutralized		42	.200	55.00	—0.66
5	.350	55.63	42	.350	50.13	5.50
5	Neutralized		42	.100	56.10	—0.47
6	.500	57.56	96	.560	53.41	4.15
7	.250	56.74	48	.250	55.51	1.23
8	.250	60.14	56	.250	56.19	3.95
8	Neutralized		56	.000	60.12	0.02
4	.800	50.94	96	.800	43.94	7.00

These tests show that there is a very decided danger of inversion while boiling low-grade products if they are not kept nearly neutral. A definite relationship between acidity and inversion has not been established, though in general it is easily seen that the higher the acidity, the greater is the inversion.

Especially in the cases of molasses, individual variations prevent any attempt at formulating a fixed rule as to the danger point in acidity. Thus molasses No. 3 has over twice the acidity of No. 8, but has lost only a third as much by inversion. Such discrepancies must be ascribed to qualitative differences in the acids or salts present.

The massecuite ran rather more regularly, and I believe it would be safe to say that any cane massecuite of over 0.250 acidity is in considerable danger of losing sugar by inversion. In this connection it is interesting to note that the massecuites as a rule suffered much more than molasses of like acidity, probably on account of the greater concentration of neutral impurities in the molasses, which would tend to reduce the inverting power of the acids.

A conclusive proof of the effect of weak acidity in causing inversion, one which is free from the suspicion of being due merely to individual variation, or to decomposition by heat alone, is given by the behavior of massecuites after neutralization. Samples which ordinarily suffered a marked drop in purity on heating were, by neutralization with dilute sodium carbonate solution, rendered practically immune to this loss.

The practical bearing of this is readily apparent. A drop in purity of two points, caused by inversion of second massecuites, means a loss in available sugar of over 5% of that present, which would amount to a good many thousand dollars in a year's run in the average factory.

I believe this is important enough to warrant further investigation. It may account for a great many of our so-called "unknown losses." Experienced sugar-boilers know that it is generally easier to get a low-purity waste molasses when running an "acid house," as the massecuites boil freer and are less viscous, but

unless great care is taken not to go too far on the acid side, there is grave danger, as my figures show, of causing a drop in purity through inversion. Where steam is used in the centrifugals it may be the cause of a further drop in purity of the waste molasses, if this is acid, which would fictitiously indicate an increased recovery, at the same time causing an extra charge to "undetermined" losses.

As a preventative I suggest that we establish a regular system of acidity control, using a standardized method for all the mills, and covering as completely as possible the various stages from mixed juice to final molasses. Many mills have not sufficient laboratory help for all this. They could at least keep composite samples of first and second massecuites and have them titrated weekly, and if these composite samples were run weekly for both apparent and gravity purity, I believe the control would be very much helped, as most mills have a very good idea of the purities that go to make up their pan material.

There is also a possibility of losses from this cause occurring all through the period of manufacture, and unless the control has been kept very close and a good system of technical bookkeeping used, it is very hard to have even an idea of how great these losses may have been and where they occurred.

SUMMARY.

Second massecuites and molasses from several different mills were heated at 65° C for several days. In some cases a marked drop in purity, indicating loss by inversion, occurred, this loss being somewhat proportional to the initial acidity of the sample, and almost entirely preventable by neutralization with sodium carbonate before heating. Acidity determinations should be included in the routine sugar-house control work.

Report of Committee on Curing and Marketing.*

By WM. LOUGHER.

A list of questions was sent out to members of the Association and replies received from sixteen plantations, which I submit in full. These replies convey a great deal of information on the subjects, and are another step towards establishing methods of control of massecuites and the sugars thereof.

This stage of manufacture was very thoroughly taken up by our committee of last year. The questions and report of the committee of this year no doubt appears to contain a great deal of repetition. But, the fact still remains that the majority of the factories has still to make big advances in devising and adopting methods that will facilitate the boiling and particularly the separation of the molasses from the sugars. It is a question whether this can be improved by a single method applied in all factories, or whether each individual factory should develop a method of its own, to meet the conditions prevailing in boiling-house equipment, and the nature and quality of the juices in their immediate locality.

Following the replies are a few remarks.

QUESTION 1: What method if any have you used to keep the polarization of the shipping sugar at the most profitable point?

G. Giacometti:

We control the polarization of our sugar by the purity of the massecuite and washing in the centrifugals. As long as the shipping situation is not improved, I think that within reasonable limits the preference should be given the deterioration factor of the sugar, over the most profitable polarization. As a general rule a sugar of the most profitable polarization at the time of bagging means higher impurities and moisture, and it cannot be expected to keep as well as a purer product when subjected to long and unfavorable storage, etc.

R. C. Pitcairn (answers to Nos. 1 and 2):

As the most profitable ultimate extraction with an economical use of fuel is the point we are working for, I believe these two questions can be best answered together, and I personally believe the following system can be adopted here on the Islands in the handling and manufacturing of 96 sugar:

The 96 pan grained to as low a purity that will give a 96 sugar and as low a resultant low molasses that can be used in one low-grade boiling to turn out a low final molasses, bearing in mind the fact that the amount of water used in washing would not exceed the amount you would have to add on your pan floor, providing you do not wash your sugar.

To facilitate the washing of the centrifugal machines, I believe in automatic washing machines, as they give an evener purging and a sugar that discharges evenly from the machines and will tend to standardize the entire output and eliminate dirt and the human element and save sugar from being washed through the screen as by the old hand method, and the minimum of water can be used, this water also facilitating the curing of the sugar. I also believe that automatic dischargers should be used, as they not only save time (we have dumped seven machines with a discharger to five without), but they also serve to standardize the work, obliterate skilled centrifugal men, and are an aid toward cleanliness and give an even feed to the sugar elevator.

Regarding screen trouble, this depends entirely, in my opinion, on whether the screen backing and screens have been properly adjusted.

W. Ebeling:

The same old style, except a larger crystal, adding molasses to get 96-96½.

D. W. Richardson:

I try to keep the shipping sugar as dry as practicable and as near 96 polarization as possible.

J. P. Foster:

We have for some years past regarded it most satisfactory to make a sugar of just above 96 polarization, believing that in the long run to be the best policy.

J. W. Donald:

Keeping the polarization around 96½ (the most profitable polarization under present contract) by regulating the quantity of molasses "taken back."

H. D. Beveridge:

Boil massecuite that will yield 96-96½: polarization sugar of good size, uni-

form grain without any washing in the centrifugals. Such sugar, we believe, is the most acceptable to the refiner. Massecuite boiled from the resultant molasses will yield a sugar of high enough purity to seed first massecuite and an exhausted molasses. This method stands for economy in steam and is simple.

E. T. Westly:

We have this season tried to keep the polarization of the shipping sugar as close to 96 polarization as possible without going below. This we have done by altering the amount of No. 1 molasses taken into the pan and also by varying the amount of water used in the centrifugals. Average polarization for the crop of 1919 is 96.364.

J. J. Muller:

We boil enough molasses back to bring our commercial sugar to as near 96 polarization as possible.

Herbert S. Walker:

We have been following the method in use here for a number of years. With high purity juices, three grades of first massecuite are boiled:

1a. A straight syrup strike started on low-grade sugar seed. Average purity massecuite, 84.64; molasses, 65.8; sugar, 96.94 polarization.

1b. Started as above, molasses from 1a boiled in. Average purity massecuite, 80.12; molasses, 59.09; sugar, 96.0 polarization.

1c. Started as above, molasses from 1b boiled in. Average purity massecuite, 77.21; molasses, 55.5; sugar, 95.22 polarization. No molasses from this is taken back. It is all grained and boiled for crystallizers.

Purities given are average for season. Average polarization sugar, 96.00.

This method would normally give an average polarization of around 97. Since 96 was the most profitable to make, we made the following modification in the centrifugal work and regulate the polarization at that point by three methods of control:

If the average gets above 96 we bring it down by washing the straight syrup strike in the centrifugals with just sufficient 1c molasses to push out the high purity molasses and replace it with the low. In other words, we substitute 55 purity molasses for the 66 purity molasses originally adhering to the crystals. This accomplishes practically the same result as if the molasses had been taken back in the pan, and saves time and pan capacity. Polarization of straight strike is reduced about 0.7%.

If juices run exceptionally high and the polarization seems to be getting away from us, we bring it down still more by treating 1b in the same way. This is very seldom done.

If juices run low in purity we stop the molasses washing temporarily.

With syrup purities of around 80 we make only two grades of No. 1.

Finally, at the end of the season, with exceptionally low juices, we sometimes wash strike 1c with a little water to keep up the average polarization to 96. This was only done for a couple of weeks last year.

S. C. Smith:

I found that a massecuite of about 78 apparent purity gives a sugar polarizing very close to 96 without washing. The objection to this is that it also

gives a No. 1 molasses of 60 to 64 apparent purity, which is too high to give a satisfactory waste molasses in two boilings. Therefore I reduced the purity of the first massecuite and washed the sugar with hot water from the evaporators, which is clean and sterile. Very little of this (from a pint to two quarts) holds the sugar at 96 polarization. I find little sugar washed away, if any, the finest, and to my mind giving a better appearing, drying and storing sugar.

G. F. Murray:

By boiling back No. 1 molasses in varying amounts, according to the purity of the syrup, yielding a massecuite of 78 purity, which in turn gives a sugar of 96-96.5 polarization.

R. J. Richmond:

By control of purity of first massecuite, average sampling and polarization of sugar bagged.

J. E. Biela:

My aim is to keep the polarization of commercial sugar between 96 and 96½, and arrive at this by returning first molasses into the first massecuite to the lowest possible purity quotient.

G. F. Renton, Jr.:

We endeavor to manufacture a commercial sugar having a polarization of 96.5, for the reason that it is our desire to manufacture a sugar that will be acceptable to the refineries; a sugar that they will not discriminate against, and a sugar that will find a ready sale in the open market. This is, however, not a shipping sugar at the most profitable point. Under the present circumstances of high prices of sugar, existing contracts with refineries, etc., a lower polarization would be more profitable, all of which has been explained in the *Planters' Record* long ago.

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From the replies, the use of molasses and remelt in varying quantities seems to be the practice generally adopted for regulating the polarization. Mr. H. S. Walker has given a clear and detailed description of their method at Pioneer Mill.

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QUESTION 2: Have you anything to offer as regards the use of automatic dischargers such as their behavior with the larger-grained sugars, toward sugar of low polarization and effect on screens?

G. Giacometti:

We have never installed automatic dischargers on account of the arrangement of our conveyors, elevators, etc. My personal opinion, from what I have seen and heard, is that the advantages and disadvantages of these machines are still a matter of discussion, and it is still an open question in my mind if automatic dischargers are here to stay or not. I understand that in one large mill at least they have been discarded after years of experience.

R. C. Pitcairn:

Answered with Question No. 1.

W. Ebeling:

No knowledge of same.

D. W. Richardson:

I have never had experience with automatic dischargers in drying raw sugar. They work very satisfactorily with white sugar. I have never noted their effect on screens.

J. P. Foster:

We have no experience with sugar dischargers, other than in the use of self-discharging machines for our shipping grade of sugar. These we find to be very satisfactory.

C. Budde:

We use Roberts-Gibson sugar dischargers on all our machines, raw and white, except the low-grade ones, and they give good satisfaction.

J. W. Donald:

We have not used centrifugal dischargers here.

H. D. Beveridge:

No experience with self-discharging centrifugals. We are using Mackin-tosh unloaders to unload first sugar from 40″ machines. These unloaders are easy to operate and give very little trouble. Two can do the work of three by their aid. We never noticed any injurious effects to the grain from their use. Have not tried them on low-grade sugar. We have been using the same screens for two seasons, and they are still in good condition.

E. T. Westly:

Have never had any experience with automatic dischargers.

J. J. Muller:

Never used automatic dischargers, but believe them to be a good thing.

H. S. Walker:

No.

S. C. Smith:

The only experience I have had with dischargers has been in white and raw beet sugar, where, with reasonable care, what little wear and trouble was caused to the screens was more than offset with the speed gained and the fact that it was easier to keep the men on the machines, also as no particular strength was required, could more easily pick up men.

G. F. Murray:

I have had no experience with automatic dischargers in cane sugar mills.

R. J. Richmond:

Have only used the automatic discharger in an experimental way, having it installed on one centrifugal. We found an average gain of 19 seconds in discharging by automatic against hand. We had some trouble with the plows damaging the screen, which, however, is obviated by having the patent lock screen. The discharger worked well on free, good-grained sugar, but sticky No. 1 sugar, which ran hard in the baskets, the plow would not enter, and the sugar had to be cut away with sticks or paddles, to allow the discharger to complete the empty-ing. I believe there is another patent addition to the discharger, in the shape of

another scraper at the heel of the plow to start hard sugar, but we haven't got it yet. I believe with fairly intelligent operators and a large output the dischargers would be of great use. We did not consider the initial cost warranted the installation. Our discharger was manufactured by the Boston Machine and Tool Co.

We did not try it on low-grade machines. They are all 30″, while our No. 1 centrifugals are 40″.

J. E. Biela.

I have no experience with them.

G. F. Renton, Jr.:

We use the Gibson sugar dischargers on the 40″ centrifugals, drying our commercial and No. 2 sugars. The larger the sugar grain, the easier it is to discharge the same from the centrifugals. On our No. 2 sugar the paddle of the discharger is narrower than on the high-grade sugar, but these dischargers shorten the life of the centrifugal screens considerably.

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The experiences seem to be rather varied with mechanical dischargers. The advantages of their use have apparently not excited any great demand for new installations. Larger-grained sugars should not offer any detriment to their use. The patent lock screen made by the American Tool & Machine Co., being used in some of the factories, has helped to diminish the screen trouble, but to make the discharger more successful the use of a much heavier screen is necessary, to resist the thrust in cutting down a sugar that has been dried in excess of what is customarily considered good discharging condition; this condition is the result of careless or inexperienced operators. Should damage occur to screens in discharging under the above condition, the immediate tendency of the operator is to under-dry the sugar, giving a better discharging quality, with an increased moisture, thus developing a condition interfering seriously with the keeping qualities of the sugar.

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QUESTION 3: A. Do you cool or dry your sugar? If so, how?
B. What is your opinion as regards such practice in respect to accurate weighing of sugar, behavior in bags during storage and shipping, and keeping qualities of sugar?

G. Giacometti:

A. We cool our shipping sugar by passing it through a Hersey drier without steam.

B. Our experience as regards deterioration of sugar has been that the moisture absorbed from the air is the principal cause of wetting. We found that a closed warehouse *without any ventilation* is the best place to store sugar, at least in our district.

R. C. Pitcairn:

We cool our sugar with a fan wheel to 38 degrees centigrade and it keeps well in storage.

W. Ebeling:

A. Only what dries out or cools in the bin.

B. This question is hard to answer, as sugar will stick and accuracy in weighing is at a premium. The sugar in bags during storage is all that could be expected. We had some stored for two months in the sugar-room, which seemed in the pile to have caked, but when we handled these the sugar became loose, with not one bag wet or stained. In the new warehouse built last crop, I have had to rebag about 400 bags, as they used green boards on the cement floor as dunnage. The bags of warm sugar drew the moisture from the boards, with the result that the bags on the side next to the boards were wet. The sugar remained loose without caking. Polarization, 96-96½; moisture, 0.8 to 1.0%.

D. W. Richardson:

A. Our sugar is partially dried and cooled by falling as it leaves the conveyor upon a revolving disk which throws and scatters it as it falls into the bin.

B. I believe with a dry, cool sugar the weighing can be done more accurately and the keeping qualities during storage and shipping will be the better.

J. P. Foster:

A. We have not dried our sugars in the past, but expect to do so in the future, by means of running them through Hersey driers, without steam.

B. I do not anticipate that this procedure will have any other effect than to prevent the caking in the bags. I would not expect it to have any effect upon the weighing of the sugar nor upon its keeping qualities.

J. W. Donald:

A. No.

B. My opinion and experience are that cooling the sugar has no influence on the accuracy of weighing nor on the keeping qualities of the sugar, but has a pronounced influence in preventing the hardening, or caking, of the sugar when stored in piles.

H. D. Beveridge:

A. We do not cool our shipping sugars, but send such sugars to the pile without cooling. The results are that the sugar cakes in the bags and causes inconvenience in shipping and the destruction of a large number of bags through breakage.

B. We are looking for a good cooling system and would appreciate any contribution or information regarding such.

E. T. Westly:

A. The sugar after leaving the centrifugals is shaken into a bucket conveyor by a grasshopper conveyor. It is then taken up about 35 feet to the top of the sugar bin. As the sugar drops from the buckets, it hits a rapidly-revolving circular iron plate. This plate, studded with $\frac{3}{8}$"x 4" iron fingers, sprays the sugar against the sides of the bin. Our bin is located up under the roof, and it is a rather hot place.

B. Formerly our sugar was bagged directly from the centrifugals and weighed. There was then always a drop in weight of about one-half pound per bag after the sugar had been stored for a couple of days. The less moisture sugar contains, the better it will keep.

J. J. Muller:

Never cooled or dried No. 1 sugar; it seems to me unnecessary, as long as the moisture is reduced to about 1%.

H. S. Walker:

A. Cool partially by dropping it onto a revolving plate at top of bin.

B. The cooler the better.

S. C. Smith:

A. Our sugar is cooled and dried in two sets of tandem Hersey driers, only air being used.

B. The main difficulty I had has been caused by getting the sugar too dry for the size of containers we use. Our average polarization was 96.12, and moisture 1.20%. If I lowered this average moisture the adhering molasses seemed to stick on the grains, causing them to hold apart and giving to the sugar a fluffy appearance, making it very difficult to pack in the bag the 125 lbs. The sugar has been very good in keeping quality, not caking in the stacks.

G. F. Murray:

A. We do not cool or dry shipping sugar. It is bagged hot and piled in sugar-room for about 24 hours; from there it is hauled to warehouse to await shipment.

B. No experience.

R. J. Richmond:

A. We cool our sugar slightly by elevating by the usual bucket elevator, passing it along a short conveyor belt and discharging it into a bin, from whence it is bagged, the effect of which on the weighing is difficult to estimate. One advantage, however, by passing through the bin as regards weighing is that as we pass the sugar first through a Richardson automatic scale, then over a platform scale, we can regulate the speed of the weighing. As to the behavior in bags, though we do not have at any time much sugar in bags on hand in the warehouse at the mill, I have had no complaints from Mahukona (our port of shipment) as to the hardness of sugar in bags, and our returns show a satisfactory polarization as compared with mill.

J. E. Biela:

A. No.

B. I believe strongly that if sugar is cooled before bagging, the difference in regard to weights between the local factory and the refinery will be partially eliminated, and the sugars will keep better in storage and during shipment.

G. F. Renton, Jr.:

We cool our shipping-grade sugar by passing same through revolving Hersey driers (no steam used), followed by a storage for a short time in a sugar bin. This cooling of the sugar makes more accurate the weighing of our commercial sugar, prevents caking in the bags, and improves, considerably, the keeping qualities of our sugars.

———

There is unquestionably an advantage in cooling the sugar before bagging. The replies seem to be of a conflicting nature, one of which indicates a difference

of half a pound per bag, while a few consider cooling has no influence on weighing and keeping qualities. In all instances where cooling has been practiced there seems to be an advantage, in that it prevents the caking in the bags. It has been generally accepted that where the deterioration factor is in excess of reasonable limits of practice, the deterioration point of the sugar is hastened. Therefore, any drop in moisture from cooling or drying between the centrifugals and the bag cannot be considered but an advantage to the keeping qualities of the sugar.

QUESTION 4: A. What, in your opinion, is the best way to weigh sugar?
B. Have you found automatic scales to be satisfactory and accurate?
C. Have you found automatic scales to be an advantage over the regular platform type scale?
Give a brief description of advantages or disadvantages experienced with both.

G. Giacometti:

We weigh our sugar by hand over ordinary platform scales and we check the weigher by reweighing occasionally several bags selected at random. I really think that any system of weighing is good providing that the scaler is good.

R. C. Pitcairn:

At Wailuku the system of weighing is as follows: it is fed from a feed-box to a Richardson automatic weighing machine, and then onto a Howe scale, each bag being allowed to balance on this. This scale is also checked daily against a Fairbanks scale and standard weights. This system seems to work nicely.

W. Ebeling:

Hand weighing would be the best and most accurate. But as the bags are broken in shipping, this would be expensive. As we are doing now is less expense. We have to be satisfied anyway with the weight we get from the refineries. To my belief, after the automatic scale has done its duty, the accuracy has to be taken for granted. If we could get the loaded cars weighed, we would know the difference from the single weight.

D. W. Richardson:

A. The best way to weigh sugar, in my opinion, is to weigh it accurately. As regards rapidity and accuracy, I do not know the best way to weigh sugar.

B. I have not used automatic scales in weighing raw sugar. I have found, with white sugar work, these scales are accurate enough, but require a regular routine checking.

C. The only advantage over the regular platform scale is in gaining time, i. e., rapidity of working and less labor.

J. P. Foster:

A. By automatic scale.

B. Yes.

C. Yes, given a satisfactory type of automatic scale with reasonable attention. I cannot conceive of any disadvantages as compared to platform scale, while the advantages are numerous.

C. Budde:

    A.   Automatic scale.

    B.   Yes.

    C.   Saving of time and labor.

J. W. Donald:

    A.   By the quickest and cheapest method.

    B.   Yes.

    C.   A good type of automatic scale is a decided advantage over platform scales, except where each bag must be absolutely exact. Owing to the varying quantities of sugar which stick to the apparatus between weighings, there is a difference in weight between individual bags which may amount to one-half pound, either under or over weight. But over a number of bags the average will be found at least as accurate as by ordinary hand weighing. For local sales, or where each bag must be exact, careful adjustment by hand is necessary—a procedure which is not practicable for rapid and economical work.

H. D. Beveridge:

    A.   By hand on sensitive, checked, platform scale. Sugar cooled before weighing. Weighed again on platform scale in large lots before shipping.

    B.   Not on hot, sticky sugar.

    C.   We tried a Richardson automatic scale on sugar at Honomu, but discarded it for the platform scale on account of inaccuracy.

E. T. Westly:

    A.   Have only had experience in weighing by hand on a platform scale.

    B.   Never used any.

    C.   Never used any.

J. J. Muller:

    Never used automatic scales, but from other reports made at other meetings do not consider them entirely satisfactory.

H. S. Walker:

    The most accurate way would be to weigh each bag on a platform scale, but to get the best results would probably require a luna to do nothing but check up weights and scales.

    The most convenient way is with automatic scales. They average up fairly well if carefully adjusted for each strike. Whatever kind of scale is used should be checked up with standard weights during the weighing of each strike.

S. C. Smith:

    A.   I believe, outside of a quick-acting and accurate scale, much can be done to promote speed and correct weighing by having the bagging station arranged so that the least possible handling be necessary, which gives more time to the men weighing to do careful work.

    B.   Have had no experience with automatic scales with raw sugar, but with granulated sugar found the Bond scale to be very satisfactory.

    C.   In granulated sugar, very much faster and more accurate than hand weighing. Made it a practice to check numerous five-bag lots. The advantages of the Bond automaic scale were speed, accuracy and as little trouble as one could well expect in any automatic device. Also, if anything, there was less chance

for sticking up of contacts, as the scales were more tightly enclosed than the average platform scale. The regular platform scales are too slow, also contacts get stuck, and unless the weigher was very careful, inaccurate weights are numerous. We have four sets of Toledo scales, 0 to 250 lbs., graduated in 4 oz., which can be estimated quickly to 2 oz. Also one from 0 to 1000 lbs., graduated to 1 lb., for checking purposes. These work very good, and the weights check closely with mainland weights returned.

G. F. Murray:

　　A.　On platform scales.

　　B.　No.

　　C.　No. Automatic scales have a tendency to hang up with sticky sugars and need a great deal of attention to keep them in order.

R. J. Richmond:

　　A.　Using automatic scale for preliminary weighing and passing over platform scale to check up and correct weight.

　　B.　In order to get consistent weighings with the automatic scale it is necessary to have a dry free sugar which runs easily. We have found we cannot rely altogether on the automatic scale with different strikes and different rates of flow. The weight will vary from $\frac{1}{4}$ to 1 lb.

J. E. Biela:

My experience with automatic scales dates several years back, but I have seen some of them in operation occasionally; if I should use my observations as criterion, then the manufacturers of these scales wont have very many chances for the disposal of their product. Give me any time a platform scale and a reliable man and I am content.

G. F. Renton, Jr.:

The most accurate way is to weigh each bag on a platform scale. We have found automatic scales satisfactory, and are fairly accurate. The automtic scales have the advantage over the regular platform type of scale in speed in handling of the commercial sugar, but I have not yet found a system whereby the sugar can both be weighed accurately and speedily.

————

It is apparent that a very dry free sugar is necessary for consistent weighings with an automatic scale, to obtain a reasonable degree of accuracy, and is customary in factories where automatic scales are in service to check-weigh each bag with a platform scale. This does not necessarily mean extra labor, but the assumption would be from this practice that the automatic scale is not reliable in weighing a sticky, sluggish-moving sugar without considerable attention. Speed of operation seems to be considered the chief advantage, but whether its performance under all conditions would warrant their installation over any other type of scale is a matter for discussion and unbiased judgment.

QUESTION 5: Last year there was described a practice of putting 130 pounds of sugar in a bag. Do you practice this? And to what extent does it lessen the cost of containers?

W. Ebeling:

130 pounds may be O. K., but some of our burlap would have to be of better quality and the bags would have to be 40½ or 41 inches instead of 38 inches. I cannot see the economy of this, as the bags would cost about the same. There would be a saving of time in packing, and the top and bottom twine would be saved in a few bags, but there would be more breakage of bags and loss of sugar.

D. W. Richardson:

We do not practice putting 130 pounds sugar into a bag. This practice will enable us to put 4.84% more sugar into a bag, which means a saving in bags of 4.62% and which is the same thing as a saving of 4.62% on the dollar in the cost of bags. Of course, there will be some saving of bag thread, which will amount to about 9 pounds thread in 6000 tons sugar. If a saving of a fraction of a cent on the dollar can be effected by doing something that is permissible, why not do it?

J. P. Foster:

A number of years ago this company began shipping 133 pounds of sugar to the bag, which was done with the idea of making an even 15 bags to the ton. This practice was a considerable economy and was quite satisfactory from our point of view, but was abandoned because of the objections from the refiners. We did not find it necessary to increase the size of the bags to put in the additional 8 pounds, and the saving was, of course, one bag per ton.

C. Budde:

All our bags contain 100 pounds only.

J. W. Donald:

A. No.

B. Squeezing another 5 pounds into the bag will, of course, reduce the cost of containers by 5/125 or 4%. On the other hand, it will mean 15 5/13 bags to the ton, a figure which will complicate bookkeeping and render almost impossible the present practice of shipping sugar in even tons. A more logical plan would be to "cut your cloth to fit" the sugar.

H. D. Beveridge:

No. Some of our bags will hardly hold 125 pounds and sew up good with sewing machine. We think that if a bag is packed too tight the damage by breakage is greater.

E. T. Westly:

We still continue to put 124 pounds in the bag.

J. J. Muller:

Never used that method. Saving in containers would be small.

H. S. Walker:

With the poor quality jute we have been getting, we had more complaint of broken bags when we tried to crowd in too much sugar. We compromised by

making three different lengths of bags, using for each strike the size which best suited it.

S. C. Smith:

We place 125 pounds in our bags, as noted in question No. 3 B. We cannot place more sugar in the size containers we use.

G. F. Murray:

125 pounds net.

R. J. Richmond:

Have never tried 130 pounds sugar in bag; 125 pounds is our weight.

J. E. Biela:

A. No. B. Am unable to state.

G. F. Renton, Jr.:

Following the practice of 1918, we have continued during the crop of 1919, putting 130 pounds of sugar in a bag. By this practice we saved, in the cost of containers alone, approximately $5500 for the crop 1919.

———

From the replies we have but one factory reporting the practice of putting 130 pounds of sugar in a bag, with a saving in cost of containers of $5500 on approximately 32,000 tons of sugar. 125 pounds sugar to the bag appears to be the amount more generally practiced. In factories that make their own bags it would seem the most logical thing to do, to reduce the percentage of breakage, would be to purchase their burlap of a size that would permit a slight increase in the width of the container, in place of adding to its length. The greater the length or the more tightly packed the containers, the greater the tendency toward breakage.

———

QUESTION 6: A. What methods do you use to facilitate the drying of low grades?

B. If your method of boiling has an influence, such as graining on high purity liquors, cutting, etc., please include a description.

C. How long are low grades kept before drying? What style of crystallizers or tanks are used? In your opinion, do these affect the drying qualities?

D. By what changes, if any, do you think your results could be improved, either by change of methods, or rearranged or additional apparatus, whereby you believe you could secure a greater yield of or a faster working sugar?

G. Giacometti:

A. The shipping sugar is started on seed and the pan cut once. We aim to produce a grain in which the sum of medium and large is about 80%.

C. The low grades are cooled in closed crystallizers for about 6-8 days without water.

D. To facilitate curing the massecuite is diluted with water about 12 hours before opening the crystallizers. This is all that is necessary to insure good curing provided the massecuite is reasonably free from false grain. Other methods

of which we hear occasionally are, in my opinion, mostly attempts to correct poor pan work, since they all aim more or less at redissolving the false grain which prevent the mass from purging freely.

R. C. Pitcairn:

To facilitate the drying of low-grade massecuite we found this year that we could speed up over the old method of applying steam at the centrifugals by adding water directly to the massecuite at the suction end of the pump, returning the low grade from the tank to a crystallizer before dropping to the mixers. This only slightly raised the purity of the resultant molasses unless too much water was added, and was of a very great benefit.

Our low-grade massecuite has 7 to 9 days in the crystallizers and about the same time in the outside tanks. The tanks do not seem to benefit us outside of the fact that they give us practically two more days of crystallization in motion going out and coming in, and I believe a great benefit could be derived by the addition of more crystallizers. The crystallizers here at Wailuku are of the circular water-jacketed type, and we use these jackets in cooling the massecuite, seemingly with good results. We also add a little water if we have time after the massecuite is cooled, and give these crystallizers as much attention as we do the pans.

I believe an arrangement whereby the temperature of the pan can be kept at the same temperature as the feeding (water and molasses previously mixed to an economical Brix) will eliminate a great deal of false and secondary grain and will improve conditions, and I consider this extremely important.

W. Ebeling:

A.   Old style drying here.

B.   We grain on syrup and try to make a larger grain by cutting to another pan. Have found the calandria the best pan to make even grain.

C.   We are short on crystallizers, and from 6 to 8 days is the longest time we can allow. We have open crystallizers (Catton, Neill).

D.   Nothing except warm water mixed with warm molasses to keep the massecuite about 96.

E.   I believe that if we could keep the massecuite longer, say 16 days, or 5 days after pumping into tanks which would flow continuously, the molasses would show a lower purity. But the question is at present that I am not sure that we get the sugar in the bags; this may lower the purity, but the sugar may have been lost through different factors.

D. W. Richardson:

A.   Our final grade of massecuite is heated by being led over hot-water coils just before it goes into the machines.

B.   Our method of boiling is two grades of string-proof being boiled respectively from No. 1 and No. 2 molasses. As far as drying quality is concerned, this is influenced by the quality of the juice and the degree of density of boiling more than other other one thing.

C.   Our No. 1 low grade is kept in tanks from 15 to 20 days before drying. The final grade of low grade is kept from 40 to 100 days before drying. We have regular open-top crystallizers with stirring apparatus. No water cooling

jacket or cooling system attached. We have quite a variety of sizes and styles of tanks. For our No. 1 low grade we use some square iron tanks and some round wooden tanks. Some of these receive one strike, some two strikes, and some four strikes. I believe that a tank does to some extent affect the drying quality of low grades. We notice here that our massecuites from the iron tanks dry some better than those from the wooden tanks. We also notice that masse-cuites on the whole dry better from those tanks which have only one strike. Our final grade massecuites is first discharged into the crystallizers (two and three strikes to a crystallizer). It is kept here from five to eight days and then put into large wooden tanks, each holding from four to five crystallizers. I believe that a change of methods would not be practicable for us here, nor do I believe that any considerable rearrangement could be effected whereby higher yields could be gotten. Additional apparatus and a change in methods, I believe, will give us higher yields.

J. P. Foster:

We have nothing new to offer upon the subject of handling low grades, but we are now making an installation for use next year, which we believe will be of material assistance. Starting with the hypothesis that the quality of the low-grade work is determined by the vacuum-pan work, it is logical to give the pan-man every possible assistance for the betterment of his work as well as to im-prove the methods for checking him up. We are therefore putting in a large tank on the pan floor, of sufficient capacity to hold the material for practically an entire low-grade strike. Syrup, molasses and water will be piped into this tank. It will be provided with heat insulation, with steam coils and with stirring appa-ratus. In this tank will be made the mixture for the low-grade strike at the desired purity, and the pan will be charged from this tank, which will be kept continually at pan temperature while boiling operations are in progress. By this means we expect to predetermine the purity of the massecuite and be able to con-trol it within much narrower limits, and, by the temperature control of the mixer, avoid formation of false grain in the pan, with its attendant annoyance and loss of time.

C. Budde:

A. No seeding is practiced at Honolulu Plantation.

B. We have 20 crystallizers of 600 cu. ft. each. Massecuites of about 65.0 purity are kept in crystallizer as long as possible, which is only three days. Mo-lasses from these strikes have a purity of about 40-42, and are boiled string-proof into wooden tanks of 10,000 gallons capacity each. Lately, I have seeded these strikes with the very finest of powdered sugar, but cannot give any results, as I have not dried any of them.

C. Low grades boiled from white sugar molasses are kept one week in crys-tallizer with hot water circulating in the jacket. Water is shut off 12 hours befor strike goes into mixer. These strikes are of a very sticky and gummy nature, but by this method the time of drying is reduced at least one-third.

J. W. Donald:

A. Injecting steam into the annular space between the basket and monitor case of the centrifugal; in cases of very viscous massecuites, causing them to flow over heated coils on their way to the mixer.

B.   Our molasses strikes are boiled "smooth."

C.   No. 2 about seven days; No. 3 about five weeks.   Tanks are used as coolers, both steel and wooden.   These have a marked influence on the drying qualities of the low grades.   Owing to shape and material of construction, the wooden tanks cause a much slower cooling, yield a larger grain and a molasses of higher purity than do the steel tanks; the massecuites from these wooden tanks dry faster than those from the steel tanks, but it is sometimes at the cost of another boiling.

D.   Only such helps as are mentioned in "A."

E.   By a rather radical modification of the boiling-house, such as crystallizers to replace coolers, etc.

H. D. Beveridge:

A.   We make the best grain we can from 50-53 purity molasses and boil with same purity molasses.

C.   14 to 18 days in crystallizers and tanks.   Next season we hope to reduce that time to 8-10 days.   "U" type of crystallizers without jacket, no effect on the drying qualities.

D.   We mix warm waste molasses with massecuite at the magma pump, which increases the drying qualities without any great increase in the purity of the molasses.

E.   By having more low-grade centrifugals we could obtain a lower purity of waste molasses, but whether the results would bear out the expenditure is another question.

E. T. Westly:

A.   At times a little cold water is added in the mixer.

B.   Have this season boiled the third massecuite in at a higher Brix and purity.   Find that it dries much better and gives a lower molasses.

C.   As long as possible.   The second massecuite stands in cars 6 to 14 days; the third massecuite, 60 to 90 days.   About 20,000 cu. ft. of the third massecuite stands over from one season to another.   The second massecuites are kept in cars and tanks.   We have seven different kinds, ranging from 19 to 88 cu. ft. working capacity each.   They are all square, of the dumping type, with the exception of 35 that have gates on the sides and sloping bottoms, and four stationary tanks. For No. 3 massecuite we have 24 square iron tanks of 510 cu. ft. working capacity each, and 10 redwood circular tanks of 660 cu. ft. working capacity each.   We find that second massecuite kept in the four stationary tanks (they are very shallow, only 2 feet deep) dries on the average better than the rest.   We also find that the massecuite kept in cars standing in a fairly warm place of even temperature dries better than massecuite kept in cooler and more drafty places.

D.   By installing crystallizers and eliminating one boiling.

J. J. Muller:

All our low grades are boiled string-proof, No. 2 to cars, 88 to 90 Brix; No. 3 to round wooden tanks, 93 to 95 Brix.   No. 2 is kept about four to six days; No. 3 as long as possible.   We have two old boilers standing on end; these are used for No. 2 sugar and seem to me to do better work than the wooden tanks —they cool quicker.   No. 3 sugar needs a thinning out, for which purpose we use a small mixer with stirrer.

H. S. Walker:

A. Diluting with water in crystallizers.

B. Method of boiling seems to have very little influence as long as fine grain is kept out.

C. As long as possible—from 9 to 15 days, depending on speed of grinding and on juice purities. "U" crystallizers, 700 cu. ft. Water-jacketed crystallizers give better control and quicker cooling, but for the same amount of money, I would prefer buying twice as many of the open type.

D. I believe that the yield of sugar from a given massecuite depends almost entirely on the amount of water left in it. If we could handle a massecuite yielding 97 Brix final molasses we would have no trouble keeping gravity purities down to 30.

We have a couple of crystallizers in stock, boiled to 52 purity and 98 Brix, whose separated molasses runs 96 Brix and 32.4 gravity purity. To handle such stuff regularly would require about twice the crystallizer and four times the centrifugal capacity we now possess.

Any attempt to hasten drying by addition of water or heat is bound to dissolve more sugar.

We are planning next year to go back to the method of adding hot waste molasses in the centrifugals, running it in from a circulating pipe system just after a machine is started up. A few experiments indicate that this works just as well as charging in motion with molasses and massecuite together. This method appears to have some advantages over other ways of heating or diluting massecuite in that the warmed-up molasses remains a shorter time in contact with the sugar crystals than if the addition were made elsewhere.

We are putting in another insulated graining tank and are planning to insulate a couple of crystallizers for use as "pre-crystallizers." By running all our low-grade massecuite into these and stirring it while hot till supersaturation is reduced before allowing it to cool, we hope to get similar results to those produced by extremely slow boiling. If it works out we should be able to make a larger-grained low-grade sugar with less danger of false grain appearing in the crystallizers.

S. C. Smith:

A. This season about 24 hours before emptying the crystallizers I diluted massecuite with about 100 cu. ft. of 38 Bé. molasses and water heated to about 130-140° F. This is about 10% of the massecuite in our crystallizer. The molasses used was the lowest waste obtainable, or from 32 to 35 apparent purity. I also introduced some of this dilute molasses in the centrifugals along with the massecuite. The objection I have to the placing hot molasses in crystallizer is that it is in for too long a period before it is machined, and causes a rise in purity. We also use steam in our centrifugals. With fast-drying massecuite this has little effect in raising the purity of waste molasses, but on slow-drying massecuie it does decidedly.

I also devised some bands to place top and bottom of screens which stopped sugar leakage at these places, and the lap thus materially reducing the waste molasses purity. Also, as this holds the screens firmly in place, it saves their breakage caused by constant bending.

B.   There is no doubt to my mind but that the main results are obtained in the pan, for if the massecuite has not been handled at the pan to give the right grain, purity, Brix and temperature, there is little use to try and dope it up elsewhere.   The fundamentals are to have the No. 1 molasses purity and Brix at the closest proper point—this varies on different plantations and cane—and to obtain this with the minimum of back boiling, thus eliminating an excessive percent of gums in the non-sugars.

According to the boiling-house equipment, this purity should be as low as possible, that a massecuite with proper size and number of grains be obtained to finally allow good centrifugal work and the lowest possible waste molasses.   Here at Puunene I believe at present these limits are between 50 and 56 apparent purity, with a waste molasses of 30 to 36 apparent purity and a sugar above 70 apparent purity.   I find it best in boiling low grades to boil rather hot, to obtain hard grain; as slowly as possible in pans.   Cut as many times as the nature of the grain will permit, and drop between 98-99 Brix at as low a temperature as possible.

C.   From seven to ten days.   Twelve jacketed crystallizers, and 18 single-shell, 9 feet diameter by 20 feet long, of 1200 cu. ft. capacity, with two more single-shell crystallizers to be installed.   I found in handling crystallizers in beet-sugar factories that the use of jackets made little difference with the final results. But I believe that, with the heavy densities and low purities used here, the use of cold water on the jackets might be beneficial to speed the final drop in temperature which causes further concentration.   I obtained the following temperatures in one cycle of a single-shell crystallizer:

Hours Filled	Counter Days	Temp. F.	Top Temp. F.
. . .	. . .	134	134
24	1	124	124
48	2	114	114
72	3	111	110
96	4	108	106
120	5	105	104
144	6	102	100
168	7	100	100
192	8	98	98
210	8¾	96	96

The helix was in constant motion, one revolution in 2 minutes 40 seconds. Brix, 98.80; polarization, 56.50; purity, 57.2.   Thus it is seen that the main temperature drop was in the first 48 hours, and the temperature within the massecuite was about the same throughout.   I believe that if on the third or fourth day cold water could be put on the jacket, the massecuite would cool off and make a shorter cycle possible.

D.   As the purity of the massecuite is lowered, the necessity arises to increase the Brix to obtain the yield of sugar.   This naturally increases the load on the shafting and, incidentally, the power required.   In our case we have to run the crystallizers alternately because otherwise the motors are overloaded.   Better re-

sults are obtained in low massecuites in motion than in standing, as it brings the sugar in contact with the sucrose in the mother liquor of the massecuite and allows it to build more. Speed is not essential to this, and I know that as good results are obtained with a helix making a revolution in five or six minutes as in, say, our case, 2 minutes and 40 seconds. I think, then, our results would be better by constant motion; in this case it could be gained by reducing the speed and with no increase, but probably a decrease, of the power required.

Will arrange to control the No. 1 molasses Brix, to my storage tank, and to increase the temperature of the first part of the building of the grain. Both of these factors are best obtained by experiment, as conditions are not the same in any two boiling houses.

G. F. Murray:

A. Exceptionally stiff massecuites are diluted slightly with water on the way to mixer. This speeds up the drying considerably, but also raises the purity of the molasses about 2%.

B. A charge of No. 1 molasses is boiled blank and dropped to a graining tank. After about 12 hours it is drawn back into pan and used as seed for succeeding low-grade strike.

C. No. 2 massecuites are kept from 10 to 14 days before drying. The crystallizers are of the usual closed type, holding 400 cu. ft., stirrers making one revolution in two minutes. Our tanks are of redwood, 1400 cu. ft. each.

R. J. Richmond:

A. I have a system of pipes at the bottom of the low-grade supply tank for low-grade centrifugals (mixer), through which hot water from Deming heaters circulates, and find quite a marked difference in drying when we use the water to drying at night, when we have none.

B. Have tried graining on syrup (for No. 2) and building up on molasses, but found, though giving a better drying sugar, the purity of the resultant massecuite was too high for good exhaustion.

C. From eight to ten days for No. 2 (cooled in motion) and one month for No. 3 (at rest in tanks). This is as long as we can afford, owing to capacity being limited to that time, also owing to that capacity being cut down by having to return condenser water. We use the crystallizers for No. 2, and iron and wooden tanks for No. 3. I think that it is rather difficult to say as to the influence of the type of tanks or crystallizer on the drying qualities of the massecuite. I have had low grades from tanks dry even better than those from crystallizers, but the exhaustion was not so complete. A certain period of rest after crystallization is completed would be beneficial to better drying if capacity avails.

D. By increasing capacity for low grades (which we are carrying out this season by the installation of additional crystallizers) and the enlarging of discharge pipes for low grades from vacuum pans whereby these strikes may be boiled to a higher density without too much time being lost in running off. A mixer where stiff low-grade massecuites could be diluted and mixed with waste molasses and rendered easier of manipulation in centrifugals and facilitate drying.

J. E. Biela:

I do not employ any special method in working low-grade sugars. Second massecuites are boiled blank into crystallizers at about 95 Brix. I do not believe

in graining low grades on high purity liquor. Adhere strongly to the advice given by Peck to those about to get married—don't. I may ask, where is the economy? First we aim at the highest possible recovery at first boiling and the elimination of possible third boilings. And then we introduce high-purity liquors into partially exhausted material. Only in a very few instances has it been necessary during the last crop to add water in some of the crystallizers, such massecuite being boiled from first molasses below 50 purity. I believe that a little better working sugar will be obtained by graining second massecuites, but I am skeptical as to any higher recovery.

G. F. Renton, Jr.

By using steam injected between the curb and the revolving basket.

All our low-grades are started on a syrup grain footing, and if, perchance, the grain is too small, a strike is cut, forming a slightly larger grain to facilitate the drying. The massecuite is kept in crystallizers in constant agitation for about a week, when it is then pumped to large tanks, which act as "gravity crystallizers," returning to the factory in about a month ready for drying. This system of "gravity crystallization," or the system whereby the low massecuite is kept in constant agitation for about a month, results in easier purging in the centrifugals, and at the same time giving a result of molasses of low purity.

The replies indicate the procedure of methods practiced to be all of a similarity, with modifications to better adapt them to the arrangement and capacity of equipment of the individual factory. Some are contemplating extensive changes in their method for next season.

The advent of high extraction has no doubt a great influence on the recovery of the sugar from the final boilings.

Time appears to be the governing element in all operations of handling massecuites to obtain the best results. High densities of massecuite are essential for low purities of waste molasses. But the separation of the molasses from sugar of high density boilings is a problem for much thought and experiment. The application of hot molasses, water, and steam, now used as a thinning medium, has yet to be perfected, so that the time of drying is diminished, with no material increase in purity of the resultant or waste molasses.

Clarification, or, rather, the point at which it should be carried, is a matter for discussion in connection with this question. Experience has taught the sugar-boiler that the point at which he carries his liquor through the house, has considerable influence over the work, particularly the final boilings. Some factories carry their juices decidedly acid, others to a point of neutrality, or on the alkaline side. There is no question that when the liquor is carried on the acid side, you meet with greater ease of operation and handling of final boilings than with a liquor that is being kept at a point of neutrality or slightly alkaline. The question is, from which of the above conditions are we recovering the most sugar, and does either warrant its general adoption over the other. This can be best determined by closer laboratory control of the house, which should give us after a little experimenting the point that would be the most profitable to adopt.

Report of Committee on By-products.*

By S. S. PECK.

As no responses were received by your committee in reply to several inquiries, this report has been compiled from matter of previous record, and a review of two late developments in the utilization of waste molasses.

The three by-products of the cane-sugar factory are bagasse, press-cake, and molasses.

Bagasse is used as fuel, as such having a value per ton equal to a barrel of oil. Olaa Plantation is now successfully making an asphalt paper for use as mulch on fields, and it is safe to hazard will produce paper for other purposes in time. The committee has no figures to add to those already presented in the *Record*.

Press-Cake: The sole use made of press-cake is as fertilizer. Its value as such varies in the opinion of different plantation managers from five to twenty dollars per ton. The Experiment Station has completed an experiment at Paauhau in which 5 tons of cake per acre produced an increased sugar production of 0.4 ton; larger amounts did not make a compensating gain. At this rate, and with sugar at the present price, a ton of press-cake is worth ten dollars for the first crop; its residual effect must also be included, which when ascertained may give a further value.

Molasses: In 1918, 150,000 tons of waste molasses were produced, which was disposed of approximately as follows:

Shipped to mainland	60 per cent
Burned for potash	10 " "
Fed to stock	7 " "
Burned for fuel	15 " "
Thrown away	8 " "

The value of the molasses under these different methods of disposal is a little hard to calculate. That sold, less freight, will net now about $4.00 per ton. As potash, the pre-war value of German salts was 5 cents per pound of potash; this price will in all probability never be reached again, and will be at least 10 cents for a long time to come. As stock food, in 1905 Lindsay of Massachusetts gave a value to cane molasses of $22.50. Under present conditions of cost, this would amount easily to $40.00 per ton. At the Hawaiian Commercial & Sugar Co., a plantation-grown ration consisting of 43 per cent molasses costs $30.00 per ton as compared with imported feed costing $85.00, a saving of $55.00 per ton. As fuel, a ton of molasses is of the same value as a barrel of oil, at the present time $2.00. In addition to these methods of disposal, two others are now being practiced locally.

At the Maui Agricultural Company, alcohol and ether, forming a gasoline

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substitute, is being turned out at the rate of 350 gallons a day. A force of three men is employed, and this same force could turn out 3000 gallons. The costs per gallon exclusive of the value of molasses amount to 7.87 cents. As a ton of molasses will produce 60 gallons of this substitute, the molasses in this case is worth, with gasoline at 25 cents, and allowing equal values to gasoline and motor spirit, $10.28. This does not include the value of the fertilizing elements remaining in the wash, which amounts, for potash alone, to $8.00.

At the Hawaiian Sugar Company a camp fuel is being made of molasses and bagasse. This plant is operated by the hot gases from a potash-recovery plant, where a portion of the molasses is being burned solely for the potash. The mixture is composed of three parts of molasses and one part of bagasse, the latter being partly dried. This is placed in an oven and baked for several hours, about half remaining as a fuel which is a satisfactory substitute for coal. As coal costs up to $24 per ton, giving the bagasse a value at this rate leaves a value to the molasses of $14.00 per ton.

Very recently, laboratory experiments have been completed with open up new possibilities. During fermentation of sugar or sugar liquors as molasses, a small amount of glycerine is always formed. The chemical laboratory of the Internal Revenue Bureau at Washington has recently completed experiments directed towards increasing this glycerine production. It was found that with a suitable yeast, maintaining the fermenting solution at a correct temperature, and of an alkaline reaction, that 20 to 25 per cent of the sugar originally in the mash was converted into glycerine, the rest going into alcohol and carbon dioxide. A fermentation in large quantity gave the following result:

Sugar in original..........................	16.50 grams per 100 cc.	
Glycerole in mash........................	3.34 " " "	
Alcohol	6.45 cc. " "	

The report states: "It must be borne in mind that there is considerable alcohol produced in these fermentations. At the present price of alcohol it is safe to say that the value of the alcohol balances the cost of all materials and overhead charges entering into the production of the fermented mash. This being true, then the slop from the alcohol distillation which contains the glycerine is had free of cost, so the only cost to be considered for the glycerine would be that of purification and distillation. This should not be great." In an actual run, with inefficient apparatus, half of the glycerine in the mash was recovered. The principal use of glycerine commercially is in making explosives. Dynamite glycerine is quoted in the New York market at 18 to 19 cents per pound. According to the experimental yield in mash, a pound of sugar will give 0.2 pound of glycerine and about 0.05 gallon of 95% alcohol. A ton of molasses with 50 per cent sugars will therefore be equivalent to 200 pounds of glycerine and 50 gallons of alcohol.

The August number of the Journal of Industrial and Engineering Chemistry for 1919 contains an article on the possibilities of making acetone from waste molasses, both beet and cane being used. Acetone was used in large quantities during the war in treating airplane wings and in the manufacture of cordite. It has been ordinarily prepared by the dry distillation of wood; and in a more ex-

pensive manner from calcium acetate, which was produced in turn from acetic acid obtained by the oxidation of alcohol. Fermentation processes have already been developed, but possessed the undesirable quality of producing twice as much butyl alcohol as acetone, and there is but a limited demand for this alcohol. The writers of the article describe an organism which produces acetone and ethyl alcohol, and give in detail the experimental results. The yield were 8 to 9 per cent of the original sugar as acetone, and 22.4 per cent as ethyl alcohol. This is equivalent to 80 pounds of acetone and 32 gallons of alcohol per ton of our molasses. Acetone was quoted in July in New York at 13 to 16 cents per pound.

The costs of production of these products have not yet been established. It will be, however, of possible interest to collect the value of the different products as represented in a ton of molasses, without attempting to arrive at the actual profit from such treatments. For the purpose of completeness, all the methods of disposal will be included.

1. Sale to mainland, at $4.00 net..$ 4.00
2. Burn for potash, 4% potash, at 10c per pound.............................. 8.00
3. Use as fuel oil, at $2.00 per barrel...................................... 2.00
4. As stock feed 40.00
5. As motor spirit, at 25c per gallon...................................... 15.00
6. As motor spirit, including potash...................................... 23.00
7. As camp fuel, coal at $24.00 per ton................................... 14.00
8. As glycerine and alcohol; glycerine at 18c per pound, alcohol at 35c per gallon.. 53.50
9. As acetone and alcohol, acetone at 13c per pound......................... 22.60

Molasses Burner at Makaweli.

At the Hawaiian Sugar Co.'s factory the final molasses is burned for the recovery of potash. The so-called "burner" was designed by Haldén, installed and used experimentally in 1916 with two furnaces of the following dimensions: 3 feet wide, 5 feet long and 5 feet deep, inside measurements. Before going to the furnaces the molasses is heated in iron pans placed above the fires and over the flue; it is fed from time to time into the furnaces and burns readily and with great heat. A sketch of this burner and a general description can be found in the February, 1916, number of the *Hawaiian Planters' Record*.

Two more furnaces were added in 1918 and the plant at present is able to burn 7-8 tons of molasses every day, producing about 1500 pounds of ashes or about 450 pounds of potash. Between 2000 and 2500 tons of molasses are in this way disposed of during the year, yielding 60 to 70 tons of potash.

During the Territorial Fair of this year in Honolulu, a molasses burner, built by the Hawaiian Sugar Co., and an exact model of the one used at the plantation, was exhibited and shown in operation. A first prize and a special award were given by the Fair Commission.

Connected with the molasses burner is an oven for baking a mixture of molasses and bagasse into a fuel, which is readily used in the camps. The accompanying sketch shows a brick oven 6 feet by 12 feet by 6 feet high, so arranged with double walls and openings for circulation, that the heat from the burner completely fills this chamber before going out to the smokestack. Bagasse, as it comes from the mills, is added to the molasses and mixed into a heavy mass;
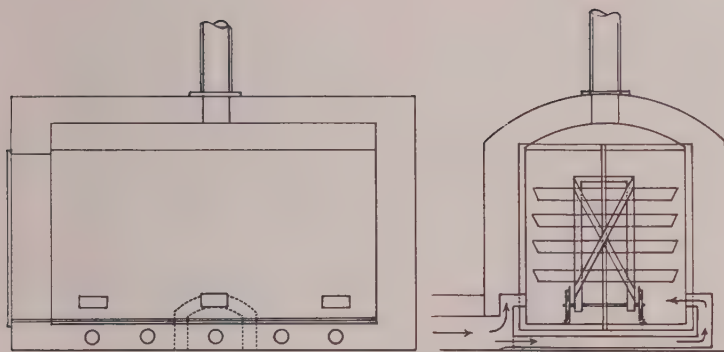
Retort for Making Camp Fuel from Molasses and Bagasse.—Hawaiian Sugar Co.

this is filled into iron pans, 5 feet square and 6 inches high, and subjected to the heat of the oven, approximately 450 degrees F. The pans are on trays, mounted on rails, and can be rolled into the oven through a large iron door. After 24 hours the content of the pans is completely charred and can be removed in a solid block. This material makes an excellent fuel and is preferred to coal or wood by the laborers.

ACETONE AND GLYCERIN FROM MOLASSES.

By G. H. HALDÉN.

"The Commonwealth (of Australia) is establishing a factory on the Brisbane River to treat molasses and lime with a view to making acetate of lime. This will be afterwards converted into acetone, which is used in the manufacture of cordite."[1]

Cordite is composed of: gun-cotton, 65%; nitro-glycerin, 30%, and mineral jelly, 5%.

Untreated gun-cotton retains to a greater or less extent the cellular structure of the material, from which it is derived, and, however much it is compressed by mechanical means, remains a porous mass and can not be used as a propellant, unless treated with a suitable "solvent," by which it is made into a colloid or gelatinized. Such solvents are: ethylacetate and other esters, acetone and like substances.

Acetic acid is formed by the oxidation of alcohol; calcium acetate is produced by adding lime to acetic acid; and acetone may be prepared by the dry distillation of calcium acetate.

E. R. Squibb[2] manufactures it by passing the vapors of acetic acid through a rotating iron cylinder filled with pumice stone and barium carbonate, the tem-

[1] "The Australian Sugar Industry," by Harry T. Easterby. **Record**, May, 1919, p. 367.
[2] Journ. Amer. Chem. Soc., 1895, 17, p. 187.

perature being maintained at about 550° C. The vapors of water, acetic acid and acetone are led through condensers, where the temperature is regulated in such a manner that the water and acetic acid condense separately from the acetone. Since the temperature (550° C.) is above the decomposition point of barium acetate, the barium carbonate employed in this process is constant.

Glycerin: Glycerin or Glycerol is a trihydric alcohol (trihydroxypropane, $C_3H_5(OH)_3$). It is found in the free state in nature mixed with certain natural fatty substances, as palm oil, from which it can be separated by washing with water, which dissolves the glycerin but not the fat.

Nearly all oils and fats found in nature are analogous to tristearin, which is glycerin with the hydrogen in the hydroxyl group replaced by stearyl, the radical of stearic acid. In soap-making the caustic soda or potash combines with the fatty acid to form soap, while the glycerin is liberated, and can be recovered from the "spent lye"; this is the usual source of commercial glycerin.

Glycerin is also a product of certain kinds of fermentation, as the alcoholic fermentation of sugar.[3] Louis Pasteur showed that 100 parts of cane sugar on inversion gave 105.4 parts of invert sugar, which, when fermented, yielded 51.1 parts alcohol, 49.4 carbonic acid, 3.2 glycerin, 0.7 succinic acid, and 1.0 undetermined.

During the war the demand for glycerin for the manufacture of nitro-glycerin was greatly increased. In the International Sugar Journal, December, 1917, page 570, is found a note to the effect that chemists in the United States have discovered a process for manufacturing glycerin from sugar at a cost of 25 cents per pound. Details of this process are given in a recent issue of this journal.[4]

The fermentation is brought about by a selected yeast (S. Ellipsoideus, variety Steinberg; No. 657 of the American Museum of Natural History, New York). The fermenting liquid is kept slightly alkaline.

20-25 per cent of the sugar undergoing fermentation can be converted into glycerin, while practically all of the remainder of the sugar is transformed into alcohol and carbon dioxide. At the present price of alcohol and raw material, the value of the alcohol balances the cost of all materials and cost, so that the slop from the alcohol distillation containing the glycerin is obtained free, and the only cost in its production is that of purification and distillation. It has, so far, not been possible to distil a crude glycerin from the molasses mashes of such a consistency and content that more than 50 per cent of the glycerin present can be recovered.

Experiments were made on the use of solutions of cane sugar and starch glucose; but it was found to be necessary to add yeast foods to these comparatively pure mashes in kind and amount as to deleteriously affect the purification of the glycerin. Therefore, molasses would seem to be more suitable for the production of glycerin by fermentation according to the process described.

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[3] Peck and Deerr, H. S. P. A. Experiment Station, Bulletin 28, p. 7.

[4] "Production of Glycerin from Waste Molasses by Fermentation," by A. B. Adams and J. R. Eoff, I. S. J., July, 1919, p. 340.

Report of Committee on Standardization.*

By W. v. H. DUKER.

Before presenting the following report to you I would like to explain with a few words why this committee was appointed and why they are making the effort to establish standard values for various stations and operations of the sugar-house.

Three years ago a circular was sent out by the Engineers' Association to the mill engineers asking for data and capacities of mill and boiling-house. At the same time the opinion of the mill engineers was asked as to whether or not they considered certain capacities ample.

For some reason or other no report was given of these data, but a general discussion of the subject was held at the meeting. It became clear then that where the question of sufficient capacities was under discussion, nobody but those directly in charge of the boiling-house could give a proper opinion.

And thus the cooperation of the Hawaiian Chemists' Association was sought for. A committee was appointed and from a number of factories the capacities of the various stations were calculated and presented to the Association last year. The writer was absent from the Islands at that time, but Mr. H. S. Walker took the report in hand at the meeting. The discussion which followed can be read on pages 16 and 17 of the Proceedings.

The general conclusion was that the work should be continued, but that, also, note should be taken of the opinion of those who handled the work. This was therefore the program for the present year, and besides a similar tabulation as was given last year, the various contributions of the members are attached to the report.

The following is a list of capacity data as established several years ago by Mr. Horace Johnson:

Juice Heaters	30	sq. ft. per ton cane hour					
Evaporators......Triple effect	215	"	"	"	"	"	"
Quadruple effect	290	"	"	"	"	"	"
Pans	55	"	"	"	"	"	"
Centrifugals......1st	3	"	"	"	"	"	"
2nd	4.5	"	"	"	"	"	"
Presses	120	"	"	"	"	"	"
Settling Tanks	72	cu. ft.	"	"	"	"	"
Crystallizers	181.2	"	"	"	"	"	"
Tanks	181.2	"	"	"	"	"	"
Total	362.4	"	"	"	"	"	"
Coolers, 1st strike, 14 days	368.2						
2nd " 60 "	1098.7						
Total	1466.9						

A copy of these data has been sent to the members of the Association, with the request to put the capacities of their mill stations alongside and to give their opinions. And thus we present herewith both the capacities of most of the mills, as well as the opinion of those who have to work with them.

There was quite a discussion last year as to what would be the most desirable way of arriving at standard figures. Mr. H. S. Walker proposed the following scheme:

From the data thus obtained (gathered from the different mills) a standard mill could be calculated. Such a standard mill is assumed to product 100% mixed juice on cane, mixed juice of 14° Brix and 85 purity, syrup of 65 Brix, commercial sugar of 97 purity. Having once established standard capacities for these fixed conditions, capacities for any individual mill would vary from the standard as follows:

For each 1% mixed juice on cane above or below 100, increase or decrease all capacities by 1%.

For each degree above or below 14 Brix of mixed juice, decrease or increase evaporator capacity by 2% ($\frac{1}{65} \div \frac{51}{65} = 1.96\%$).

For each degree above or below 14 Brix of mixed juice, increase or decrease capacities of pan, centrifugals and storage 7% ($1 \div 14$).

For each degree above or below 85 purity of mixed juice, decrease or increase capacity of crystallizers and low-grade centrifugals by 8.5% ($\frac{1}{42} \div \frac{12}{42}$).

Total pan capacity depends on weight of solids to be handled, hence on Brix of mixed juice. It should not vary with purity, though the relative capacity needed for high and low-grade strikes does vary.

As all the sugar eventually comes in the No. 1 centrifugals, their capacity should not vary with purity, but only with Brix of mixed juice.

As an example of the above, take a factory producing 120% mixed juice in cane of 10 Brix and 75 purity. Its capacities per ton cane per hour should then be:

Juice heaters and settling = standard × 1.2.
Evaporators = standard × 1.2 × 1.08.
Syrup tanks, pans and No. 1 centrifugals = standard × 1.2 × 0.72.
Crystallizers and low-grade centrifugals = standard × 1.2 × 0.72 × 1.85.

The merits of either method can best be discussed at the meeting. From a theoretical standpoint Mr. Walker's method is undoubtedly the more correct one, but for variations in quality of cane, such as are likely to occur, provisions have already been made in these so-called standards. It is quite well possible that corrections need to be made in the tabulation, as for those who sent no answer, older figures have been taken. The accompanying tabulation is the data at present available to the committee:

Top table

	Hawn. C. & S. Co.	Maui Agri. Co. *	Pioneer Mill Co. *	Wai-luku S. Co *	Kea-leku S. Co. *	Hono. Plant. Co. *	Oahu Sugar Co.	Ewa Plant. Co.	Waialua Agric. Co.	Kilauea Plant. Co.	Koloa Sugar Co. *	McBryde Sugar Co.	Kekaha Sugar Co. *	Hutch-inson Plt. Co. *	Hawn. Agric. Co.	Waia-kea M. Co. *
Calculated on a basis of tons cane per hour	130	75	70	40	30	39	100	70	65	25	35	40	31	27.5	45	30
Juice heaters sq. ft. H. S.	42	50	31	32	18.4	37.5	31	38	31	22	30	43	21	25	26	45
Evaporators— Triple		433	240	296	136	284	350	456	350	224	260	352	296	241	250	133
Evaporators— Quadruple	197															
Pans— Sq. ft. H. S.	52.5	132	53	54.6 (cu. ft.)	25.3	83.6	40	64	4.5 (cu. ft.)	35.3	46	64	39	28	50 (cu. ft.)	51
Pans— Units	6	4	3	3	2	4	3	5	3	2	3	3	3	3	3	3
Centrifugals— Sq. ft. screen area—1st	1.6	1.7	3.0	3.1	2.4	10.2	1.8	2.4	3.2	3.3	3.5	3.1	2.3	3.0	3.7	2.4
Centrifugals— 2nd	4.5	2.9	3.9	5.0	1.8		3.1	5.3	2.5	4.0	4.1	5.2	5.2	5.3	4.4	2.1
Presses— Sq. ft. filtering area	80	42.6	69	75	79	96	84	116	107	112	96	124	87	103	87	70
Settling tanks, cu. ft.	83.5	40	82	89	76	81	71	86	66	75	51	81	49	78	66	60
Low grade products storage Crystallizers	276			193		307	180	372	344		195	305	840			
Tanks	880	448	204	212			320	715			102	1000				
Total	1156	448		405			500	1087		1235	297	1305	840	1292	573	720

Bottom table

	Hilo Sugar Co.	Onomea Sugar Co.	Pepee-keo S. Co. *	Honomu Sugar Co.	Hakalau Plant. Co. *	Laupa-hoehoe S. Co. *	Kaiwiki Sugar Co.	Hama-kua Mill Co. *	Paau-hau Plt. Co. *	Hono-kaa S. Co. *	Kohala Sugar Co. *	Hawi M. & Plt. Co.	Union Mill Co. *	Halawa Plant. Ltd.	Ninili Mill & Plt. Co.	Java Factory built 1917
Calculated on a basis of tons cane per hour	40	40	30	25	35	30	25	30	30	40	26.4	40	20	15	15	55
Juice heaters sq. ft. H. S.	28	32	36	22	35	24	23.5	26	32	32	27.2	25	30	40	40	53
Evaporators— Triple	261	326	195	137	272	290	242	319	282	388	280	295	304		248	322
Evaporators— Quadruple																
Pans— Sq. ft. H. S.	60	43?	54		48.5	47	40	53	55	65	67	39	18.3	14.7	18.7	93
Pans— Units	3	3	3		3	3	3	3	3	4	3	4	2	2	2	4
Centrifugals— Sq. ft. screen area—1st	3.1	1.8	7.7	2.9	2.4	3.05	2.9	4.2	2.8	4.2	5.6	3.0	4.7	3.65	3.66	12.3
Centrifugals— 2nd	5.2	4.1		2.9	3.8	2.44	1.5	2.4	4.2	5.9		4.6			1.2	
Presses— Sq. ft. filtering area	99	108	109	96	120	86	91	79	108	122	106	70	98	88.5	112	77
Settling tanks, cu. ft.	67	74	71	84	69.5	72	72	47	80.5	66	64	22.5	77	64	61	
Low grade products storage Crystallizers			82		277.5						227	152				
Tanks			402		192.3						456	214				
Total	361	552	484	554	469.8	728	800	545	773	700			505			134

* Capacities as reported this year.

The following is a letter received from Mr. Wm. Searby, September 6, 1919:

"In reply to your letter of September 2nd, I wish to submit the following list of capacities that seem advisable at the various mill stations, per ton of cane per hour:

Juice Heaters	35	sq. ft.
Quadruple	300	" "
Triple	215	" "
Pans	60	" "
Centrifugals	7.5	" "
1st......2.5 sq. ft.		
2nd......5.0 " "		
Presses	120	" "
Settling	72	cu. ft.
Cdystallizers	181.2	" "
Tanks	181.2	" "
Coolers:		
1st strike—14 days	368.2	" "
2nd " —60 "	1098.7	" "

"You will note in the case of juice heaters, evaporators and pans, that the above capacities show an increase over the standard values proposed by Mr. Horace Johnson several years ago. This increase in capacity is recommended as it permits using lower steam pressure for boiling and provides the adequate pan capacity necessary in order to obtain the lowest practicable gravity purity in waste molasses. The increase in heating surface in the juice heaters and evaporators seems advisable to take care of the increasing amount of maceration that is being used with the higher extractions."

Commenting on the various items, Mr. Murray of Pepeekeo writes:

"Our juice heaters are ample and have given no trouble the past year.
"Our triple effects take care of juice up to 26 tons cane per hour. Above that they are too hard pushed and cannot deliver syrup above 25° Bé.
"Pan capacity for No. 1 sugar is ample. No. 2 is insufficient for 30 tons cane per hour. We should have a 15-ton low-grade pan in place of the present 10-ton pan.
"*Centrifugals:* Both No. 1 and No. 2 machine capacities are ample.
"*Mud Presses:* About 20% below standard.
"*Settling Tanks*s Ample.
"*Crystallizers:* 50% of standard. This station should have capacity for seven days cooling, whereas, normally, the massecuite is seldom cooled over four days.
"We have sufficient tank capacity for 30 tons cane per hour."

Mr. Horace Johnson writes:

"If we can get a standardization adopted to start with, it can be changed from year to year as the actual required capacities are better known. The standard must be adapted for the requirements and not the requirements adjusted to meet any adopted standard."

Mr. W. K. Orth of Koloa, criticizing the data:

Prefers 290 sq. ft. heating surface for quadruple as ample under all conditions.

He finds 46 sq. ft. heating surface for pans sufficient provided there are three units of which two are heated with live steam and the other with exhaust.

Centrifugals: Under his conditions would prefer for first, 2.8 sq. ft.; for second, 4.8 sq. ft. The average purity syrup is 81.4.

He states that 60 cu. ft. is ample for settling tanks, but prefers the standard capacity for mud presses.

Mr. Richmond of the Hawi Mill & Plantation Co. makes the following remarks:

"Taking our juice heaters first: We have three, one of 660 sq. ft. heating surface, and two of 333 sq. ft. heating surface each. This heating surface is just sufficient, when clean, to heat our juice to the proper temperature, though sometimes if we get on to a specially juicy cane and are macerating to, say, 40%, we are rather pressed and do not get a good settling juice on account of the temperature not being just right.

"*Evaporators:* In regard to the figure 295 sq. ft. heating surface for evaporator, I have taken the total heating surface furnished by all the units of the evaporating plant which consist of four cells of the pre-evaporator, forming the first unit of a double quadruple, and two sets of triple effects forming the second, third and fourth bodies of the double quadruple, the vapor from the pre-evaporator going to both sets of succeeding cells. This plant evaporates from 15 Brix to approximately 60 Brix with from 25% to 30% dilution on normal juice for the season just concluded; our clarified juice averaged 15.4 Brix, and syrup 59.8 Brix, with an average dilution of 27.

"*Vacuum Pans:* These consist of four units, three of 387, 370 and 350 cu. ft. and one of 188 cu. ft. This capacity is rather inadequate for the boiling of grained strikes of No. 2 in addition to maintaining the grain of the No. 1 sugar at the proper standard, so that we are obliged for the most part to boil our No. 2 blank.

"*Presses:* We use double pressing, and this station could be improved by more filtering area.

"*Settlers:* These are continuous settlers, and here also we are rather pressed at times.

"*Crystallizers:* We are rather limited in capacity here, too, and are also handicapped by not being able to utilize the capacity we do have on account of high temperatures of boiling; the massecuite rises and foams in the crystallizers and tanks when run off at temperature 148° to 150° F. This is generally the case when returning condensed water over cooling tower.

"Our capacity in low-grade tanks shows us higher than the standard, but I find it none too high and could do with even more.

"*Centrifugals:* Our size 40″ machines get away with all the No. 1 easily, and have time for some low-grade No. 2. For low grade Nos. 2 and 3 we have altogether 13 30″ centrifugals, which sometimes with slow drying massecuites falls behind, and we are considering putting in two more."

Mr. Biela of Kohala Sugar Co. writes:

"It is difficult to make a definite statement in regard to the merits of the capacities; for instance, our capacities enable me to do good work with between 35% and 40% maceration, when grinding Caledonia or Striped Tip cane from the upper lands and D 1135 from any locality, but are inadequate in regard to settling, presses and pans, when grinding cane from the lower lands. I believe that the ruling factor is and will remain, first, the size and equipment of the milling plant in relation to the boiling-house. Unfortunately, in most instances improvements are primarily done to the milling plants with disregard to the boiling-house. As

long as the improvements in the latter departments do not keep abreast of the former, any attempt to formulate any semblance of a standard

Take, for instance, the standards gotten up by Mr. Noel Deerr some years ago; visit about 50% of the mills, and see if you do not find practically identical boiling-house equipment, with marked improvements in the milling plants.

"You will find an excess of heating surface in our pans as compared with the given standard, but one 10-foot pan is equipped with steel calandria and tubes, thus diminishing the effectiveness of the given surface."

The following is a contribution from Mr. G. Giacometti:

"As you will notice, for 50 tons cane, the average for present season, our quantities are very close to the so-called standards, and we find them ample for the work required. The trouble, however, is when we must speed up to 65-70 tons per hour. Then, with the exception of the evaporators and heaters, we are absolutely depending on the per cent sucrose in cane and purity of syrup. This goes to show that it is not possible to set "standards per ton of cane," since we all know that there is cane and cane.

"Maybe you still remember a little calculation and table of mine where it is shown that if a certain equipment is good for 70 tons cane per hour with 88 purity syrup, the tonnage of cane must be cut to 40 tons as soon as the purity drops to 82, so as to handle the low products with the same equipment. That being the case, what must we take as a basis for our standards? Average is an academical expression when every tank is full of molasses. Must we consider the low purity as the basis of our equipment and be prepared to take everything that comes along, or figure on high purity and trust to Providence, or take a medium course of, say, 86, and when the purity drops to 82 ask the manager to slow down the mill and the rest of the plantation?

"Most of the plantations stretch the grinding season over the months when cane is properly ripe, and there is no getting away from the fact that the speed of the mill is not governed by the quality of cane, but by many other economical reasons foreign to it."

The table Mr. Giacometti refers to reads as follows, this question having been brought up in Mr. Giacometti's report on Evaporation and Boiling, 1918:

"To illustrate the importance of the purity, the following table has been compiled, in which the tons of first molasses (85.5 Brix, 56.0 purity) to be boiled into low grade per day is given for 40 to 70 tons cane per hour (13.00% sucrose and 97% extraction and purity of 82-88):

Purity of Juice	Tons Cane per Hour			
	40	50	60	70
88	36.81	46.02	53.14	64.43
86	45.39	56.73	68.08	79.44
84	54.49	68.09	81.71	95.33
82	64.31	80.39	96.46	112.54

Mr. Westly of Paauhau writes:

"Capacities that I would consider right for Paauhau mill, with our average cane, juices, dilution, sugars, and present fire-room efficiency, also present sizes and number of units:

Tons Cane per Hour...........................	30	
Juice Heaters................................	30	sq. ft.
Quadruple...................................	300	" "
Pans..	55	" "
Pans..	55	cu. ft.
Shipping Sugar Centrifugals..................	2.8	sq. ft.
Low Grade Centrifugals......................	4.89	" "
Total Centrifugals...........................	7.69	" "
Presses.....................................	138.20	" "
Settling....................................	80.50	cu. ft.

	Working Capacity	
2nd Massecuite—14 days.....................	300.00	cu. ft.
3rd Massecuite—60 days.....................	900.00	" "
	———	
Total	1200.00	" "

COMMENTS.

"*Juice Heaters:* The present standard is in my opinion ample.

"*Quadruple:* With a standard quadruple, 4 to 6 lbs. exhaust, 30-35 dilution, 12.5 Brix clarified juice of 180° F., 60.65 Brix syrup, 27" vacuum, and average amount of scale, I would say that the standard 290 is right.

"*Pans:* The standard in three or more units should be ample under average Hawaiian conditions.

"*Centrifugals:* The size, speed, arrangement of the machines, unloaders or not, method of boiling, size of sugar grains, high or low purity of syrup, would all have to be considered in establishing centrifugal capacities. Under present average conditions I think the total standard of 7.5 is pretty near right, but I would divide it differently—around 2.5 for shipping sugar and 5 for low grade.

"*Presses:* The amount of mud per ton of cane and the texture of the mud would make a big difference in the capacity at this station. Size of presses, single or double pressing, hydraulic closing or not, would all make a difference. With not over 2.5 mud per 100 cane, and having presses holding 1.5 tons of mud, the standard of 120 is about right for single pressing.

"*Settling:* Would recommend 80 as a standard at this station, with a 35 dilution.

"*Coolers for Second Massecuite:* Do not think it is necessary for second massecuite to stand 14 days. In our experience 8 days is plenty. The purity of the syrup will play a very important part at this station. The standard in your letter should be ample even with low purities.

"*Coolers for Third Massecuite:* Would be in favor of at least 60 days' standing. The purity of the syrup is of equal importance here as with second massecuite. The present standard seems ample."

Mr. J. P. Foster of Paia reports as follows:

"Replying to your circular letter of the 2nd inst., re data on standardization of boiling-house equipment, I beg to advise you that in my opinion the standardization figures referred to should be handled with a great deal of caution. Ratios which would be eminently satisfactory in one factory would be entirely out of place in another factory, due to the difference in the purities of the cane handled

or to the different methods of manipulation in the factory. In no factory is this more plainly demonstrated than in the Paia factory, as wil lbe seen by an inspection of the following figures:

"The heating surface in our boiling-house has been designed with a view to utilizing low-pressure steam exclusively, taking for that purpose the exhaust steam of an electric generator station operating in conjunction with the mill. This station takes the steam which is intended for use in the boiling-house, expands it to from one to three pounds pressure, passes it on to heating system of the boiling-house, and delivers to our electric irrigating pumps a large amount of current which we term "by-product power." This, you will observe, immediately introduces factors which are foreign to ordinary boiling-house practice in this Territory.

"Our rate of grinding varies widely, from 60 to 75 tons per hour, and I therefore have calculated each station at both figures.

"*Juice Heaters:* 3701 square feet of heating surface, 50 to 60 t. c. h.

"*Quadruple:* 26,000 square feet of heating surface, 346 to 433 t. c. h.

"*Vacuum Pan:* 9937 square feet of heating surface, 132 to 166 t. c. h.

"You will observe that these figures are from 100 to 200 per cent higher than Mr. Johnson's standard, and these ratios we find to be very satisfactory and enable us to operate these stations at practically atmospheric pressure.

"With regard to centrifugal capacity, a different condition obtains. For No. 1 sugar we have 126 square feet screen area, or 1.7 to 2.1 t. c. h. This ratio is also perfectly satisfactory, and our machines are not in operation much over half of the time. This is due to the fact that we operate on very high purity material, and further to the fact that the No. 2 cenrifugals contain 217.3 square feet of screen area, or 2.9 to 3.6 t. c. h. This amount we find to be satisfactory.

"With regard to filter-press, another marked difference obtains. We get very satisfactory service from a total of 3200 square feet of filtering area, or 42.6 to 53.3 t. c. h. It is the firm conviction of the writer that filtering area is an erroneous standard for filter-press work. It should be based upon mud capacities of the filter-press. Our settling tanks are of the continuous type.

"We have crystallizer capacity of 3306 cu. ft., being 448 to 560 cu. ft. per t.c.h. We have no tanks or coolers."

Mr. D. Nicholson of Aiea writes:

"The capacity of the heaters is 25% above the standard given. The juices might be handled with less heating surface, but not much.

"The evaporators, pans and centrifugals are above standard, but as there are large quantities of wash-water, extra syrups, molasses and massecuites due to the refining process, the capacities are not too great.

"The presses and crystallizers are below standard. The mud is handled only by resettling, then filtering. The third massecuite is kept only three days in the crystallizers, then dried.

From Mr. R. C. Pitcairn of Wailuku Sugar Co. we have the following remarks:

"*Juice Heaters:* Ample.

"*Evaporators:* Ample.

"*Pans:* Not sufficient to handle the work, due to the low purity of the initial juice and the extra quality of molasses and the fact that we have coil pans and not calandria.

"*Centrifugals:* Being compelled at different times by the amount of the product changing to throw extra low-grade machines on the high-grade side 3 ft. of the standard is all right for the first, but 4.5 ft. for the second was at all times

too low. This is a factor controlled by the original purity of the cane, the variety of the cane, and the purity one is running the low-grade massecuite at, and this figure of 4.5 was not sufficient here at Wailuku this year, and I believe should be nearer 5.5.

"*Presses:* Entirely too small. Believe 120 sq. ft. sufficient.

"*Settling Tanks:* I believe 72 cu. ft. too small, although the controlling factor in this matter I believe to be the shape and kind of settlers and the variety of cane and the amount of lime used.

"*Crystallizers:* 181.2 appears too small to me, although the amount of molasses made is a controlling factor, as is also the economical limit of crystallization, but I believe 230 cu. ft. T. C. per hour a much closer standardization figure, as this will allow practically nine days in the crystallizers, as I have found this year that, even with close attention to the cooling and treating of the second massecuite, this much time was required to derive the benefits the crystallizers were made for.

"*Massecuite Storage Tanks:* These tanks are not needed except for storage and elasticity of the control, and 85 cu. ft. would be sufficient."

Mr. Lino of Laupahoehoe Sugar Co. writes as follows:

"I believe Mr. Johnson's standards to be correct.

"You will note that our evaporator capacity is much above standard, which is a very good thing to have, as some juices form a lot of scale, and by having a large evaporating capacity can keep up with the mill at all times.

"Our centrifugal capacity for the No. 1 sugar is above standard, but for the low grade we are much below standard, and therefore have to use the No. 1 centrifugals to help dry the low grade between strikes. I am not in favor of using the No. 1 centrifugals to dry the low grades, for the reason that the perforations on the screens of the No. 1 centrifugals are larger than those of the low grade.

"The cooler capacity for the No. 2 is just half the standard, therefore am able to keep the massecuite only 7 days before drying. I believe capacity for 10 days would be ample.

"For the low grade our capacity is 495, which is far below standard, allowing the massecuite only 30 days to stand before drying. We have recently added five more tanks, which will bring our capacity to 690 and will give me about 10 more days."

From Mr. V. Marcallino we have the following contribution:

"I have taken 27.5 tons cane per hour as an average figure under normal conditions, and the data following have been calculated on that basis.

"*Juice Heaters:* Standard, 30 sq. ft.; Hutchinson, 25 sq. ft. The figure given is for the raw juice heater only. We also have a re-heater, which handles the clarified juice only, having an additional heating surface of 462 sq. ft. The raw juice heater appears to handle the work satisfactorily, though in my opinion there would probably be an improvement if same were up to standard.

"*Quadruple:* Standard, 290 sq. ft.; Hutchinson, 241 sq. ft. This does not include the pre-evaporator, which has an additional heating surface of 1878 sq. ft. With the pre-evaporator and quadruple together, we are able to handle efficiently 27.5 tons cane per hour with about 30% dilution. More has been handled at times, but in my opinion better results will be obtained when not exceeding these figures.

"*Pans:* Standard, 55 sq. ft.; Hutchinson, 28 sq. ft. While we appear to be considerably below standard at this station, it must be remembered that our low grades are boiled blank. Therefore, there is a considerable saving of time as compared to those factories where grain is formed in the pan, and where it some-

times takes as long as 18 hours to boil a single strike of No. 2. At the same time, I consider that an increase in pan capacity would be an improvement.

"*Centrifugals:* Standard, 7.5 sq. ft.; Hutchinson, 8.3 sq. ft. We are slightly over capacity at this station, but have none too much. I sometimes wish we had more.

"*Presses:* Standard, 120 sq. ft.; Hutchinson, 103 sq. ft. Slightly under standard, but O. K. for our juices.

"*Settling:* Standard, 72 cu. ft.; Hutchinson, 78 cu. ft. O. K.

"*Low Grade:* Coolers and cars for No. 2. As regards low-grade capacities, the most important factor is the purity of the juice. This holds true for most of the other stations as well.

"We appear to be considerably under standard as regards coolers and cars for second massecuite, but it is to be remembered that this factory only grinds "single time," so that we are able to keep the massecuite at least two weeks. When we are able to keep it longer, it seems to help in the drying.

"*Tanks for No. 3:* This factory is about standard at this station. Personally, I would prefer to see less third massecuite on hand, but have not been able to make much headway in this regard."

Mr. Jas. W. Donald of Kekaha sent in the capacities of his mill, and recommends for his mill:

100 sq. ft. heating surface p. t. c. h. for mud-presses, and 1300 cu. ft. p. t. c. h. for tank capacity for storage of low-grade products.

Mr. V. P. Iyer, chemist, Waiakea Mill Co., writes:

"It seems to me that in drawing conclusions as to standard capacities, one should take into consideration whether a mill grinds 12 hours or 24 hours a day, and should provide some margin, especially in a case of low-grade massecuite storage tanks, when a mill standardized for a working day of 12 hours actually grinds for 14 to 16 hours per day."

Mr. Walker of Pioneer Mill Co. writes:

"According to your request of September 2, I am enclosing actual and recommended capacities at Pioneer, based on 70 tons cane per hour, which is way above our average, but, as I understand it, capacities for maximum speed are required. We ran at this speed for three weeks last season. I have also included a calculation from our own conditions to those of a 'normal' mill.

	Standard	Pioneer Mill	Recommended	
			For Pioneer	For "Normal"
Juice Heaters.......	30	31	31	26
Quadruple (Lillie)...	290	240	280	225
Pans...............	55	53	55	40
Centrifugals—				
No. 1..........	3	3	3	2.2
No. 2..........	4.5	3.9	5	3.5
Presses............	120	69	70	70
Settling............	72	82	82	68
Crystallizers........	181.2	20	250	175
Tanks..............	181.2	...	0	...

"The calculation from Pioneer to 'Normal' conditions was based on the following data:

	Pioneer	"Normal"
Mixed Juice % Cane (highest week's run).....	120	100
Brix Mixed Juice (highest week's run).......	16.8	14
" " " (lowest " ").......	11.8	14
Purity Syrup (lowest 4 weeks run)...........	84.5	85

"Periods at the beginning and the end of the season, when we were grinding only in the day time, were not considered in the above.

"*Juice Heaters:* To get 'normal' divide 'local' by 'mixed juice % cane'.

$$31 \div \frac{120}{100} = 26$$

"*Quadruple:* Divide 'local' by 'mixed juice % cane' plus 2% for each degree Brix of lowest mixed juice below 'normal.'

$$120 + (2.8 \times 7) = 139.6.$$

"*Pans:*

$$55 \div \frac{139.6}{100} = 40$$

"*No. 1 Centrifugals:* Same as for pans.

$$3 \div \frac{139.6}{100} = 2.2$$

"*No. 2 Centrifugals:* Divide 'local' by 'mixed juice % cane' plus 7% for each degree Brix of highest mixed juice above normal, plus 8.5% for each degree purity of lowest syrup below normal.

$$120 + (2.8 \times 7) + (0.5 \times 8.5) = 143.8$$
$$5 \div 143.8 = 3.5$$

"*Presses:* I know of no reason why we need so much less filter area at Pioneer. Possibly it is in the nature of the juice.

"*Settling Tanks:* Calculate same as for heaters.

$$82 \div 120 = 68$$

"*Crystallizers:* Same as for No. 2 centrifugals.

$$250 \div 143.8 = 175$$

"Having once established a standard of capacity for a normal mill, the necessary capacity for a mill working under different conditions may be calculated just the reverse of the foregoing. For instance, assuming the above capacity for a 'normal' mill had been decided on, what would be the necessary capacities per ton cane hour for a mill making 130% mixed juice on cane, highest Brix mixed juice 16.0, lowest 10.0, lowest purity syrup 78.0?

$$\text{Juice heaters } 26 \times \frac{130}{100} = \dots\dots\dots\dots \quad 34 \quad \text{sq. ft.}$$

$$\text{Evaporators } 225 \times \frac{(130 + 8)}{100} = \dots\dots\dots \quad 312 \quad \text{" "}$$

$$\text{Pans } 40 \times \frac{(130 + 14)}{100} = \dots\dots\dots \quad 52 \quad \text{" "}$$

$$\text{Centrifugals No. 1 } 2.2 \times 144\% = \dots\dots\dots \quad 3.2 \quad \text{" "}$$

Centrifugals No. 2 $3.5 \times \dfrac{(130 + 14 + 59.5)}{100} = \quad 7.1$ " "

Settling $68 \times 130\% =$ .... 88 cu. ft.

Crystallizers $175 \times 203.5\% =$ .... 356 " "

"You will notice the considerable difference between some of these latter figures and those given for Pioneer and for a 'normal' factory.

"I believe we will find it very difficult to give due weight to the recommended capacities from different mills unless some such method of reducing them to a common basis is used."

From the data herewith presented it becomes clear that the question of adopting standards for boiling-house equipment has not become any less complicated; in fact, it will always remain a rather difficult task because conditions vary so much. However, we must keep in mind that when we express ourselves on the proposed figures we refer to average figures. I would call average conditions of cane and juice such as are reported in the annual synopsis of the H. S. P. A. Experiment Station.

Even if we cannot all agree and arrive at definite conclusions this first time, I believe the study of these subjects is very useful. We should yearly record for the sake of reference the capacities each mill has.

To test out whether or not certain standards are sufficient means a further standardization of the various operations of the boiling-house work. And this is, to my mind, a very practical and successful method of increasing the general efficiency of the factory. We may even go one step further and analyze our laboratories. How are they equipped and arranged?

What are the essentials of a standard laboratory? By this I mean a laboratory so ararnged as to turn out the highest quality and quantity work with the least effort or waste.

Our work in the sugar laboratory is largely a question of routine, and every single operation can easily be standardized.

The following is a contribution I received from Mr. de Villele, chemist at Paauilo. It gives an idea of how a laboratory should be arranged to do the routine work with the least useless running back and forth, and gives the chemist an opportunity to watch and control the work of his assistants:

Study of a Standard Cane Sugar-House Laboratory.

"Two entrances.

"Three sets of windows—1 lighting the juice department and desks; 1 refractometer, microscope and scales; 1 the operating room.

"One dark room (for polarization and supply of chemicals).

"Juices Departments—1 sample corner; 2 sink; 3 cooling tank; 4 spindles corner; 5 filtering station; 6 clean glassware and filter paper; 7 dark room; 8 dirty glasses; 9 waste samples to be returned by monte jus; 10 results.

"Bagasse, Cane and Fiber Department—1 chopping machine; 2 scale; 3 digesting; 4 scale; 5 oven; 6 weighing digested bagasse; 7 polarization; 8 weighing dried bagasse; 9 results.

NORMAL CANE SUGAR LABORATORY

Scale = 10 Feet

P.V. de Villele
Paauilo, Hawaii 8.23.19.
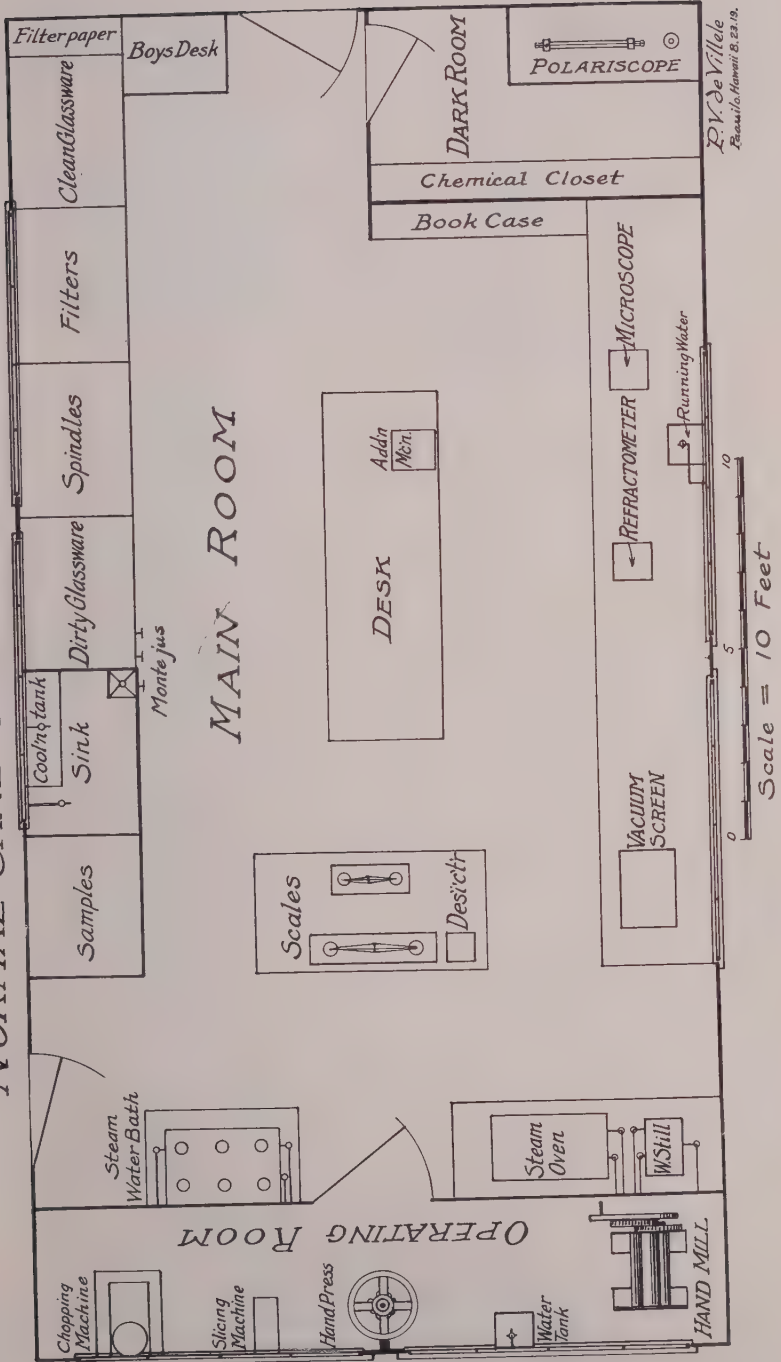
"Syrup, Massecuite, Molasses, Sugar—1 weighing; 2 dissolving; 3 juice department again; 11 Clerget operations; 12 refractometer; 13 microscope examinations; 14 results."

Hoping that this report will tend to lead us a step further in adopting definite figures for required capacities in the sugar-house, and thanking those who have sent in their contributions and have given their opinions,

W. v. H. DUKER, Chairman;
H. S. WALKER,
HORACE JOHNSON.

Electricity in the Sugar Mill. *

By E. P. GIBSON.

A number of papers have been presented before the Association on the subject of Electricity in the Sugar Industry. They have dealt, to a large degree, with a comparison between steam and electric drive. In the discussions we agree that the electrification of certain auxiliaries, such as pumps, crystallizers, conveyors, mixers, compressors, etc., is advisable. This is evident from the fact that many of the mills have installed such equipment or are contemplating doing so. We are not yet ready, however, to apply electric drive to the rolls. It is true that some of the mills in Cuba have done so with satisfactory results, but the differences in milling conditions here and there make many practices non-applicable to both places.

Beginning at the point where we are willing to accept the electrification of the auxiliaries, let us treat in this article some of the questions that arise in the installation of such material. Although these are engineering questions, the chemists' and the engineers' problems interlock so closely that discussion of the subject should be of interest to both.

In all practices we are striving for standardization. Applying this to our electrical installations we find that it has its advantages.

Alternating current, of course, should be standard. Alternating-current motors are more rugged in construction, require less attention, and are better suited for mill work than the direct-current motors. The initial cost per horsepower is less for both the motors and the wiring when comparing alternating current to direct current. The time is not far off when all plantations on each island will be inter-connected by transmission systems, and this is only made possible through the use of alternating current. It was only a few years ago that the various power companies on the mainland depended on their own power to supply their needs. We now find large districts so tied together that any company within the district can be fed from one of its neighbors, thus assuring con-

tinual service to its consumers. When all of our mills come to electrification, such connecting lines would, at times, prove advantageous.

Three phase, sixty cycles should be the next standard. Three phase is now a national standard. Sixty cycles gives a good combination of speeds for the motors.

The question of motor voltage is a matter of opinion. There are two possibilities, namely, 220 and 440. The writer would prefer 440 as a standard. The cost of wiring materials per horse-power is almost half that of 220 volts, the motors above 25 HP. cost less, and personal danger and fire hazard is no greater with 440 than 220. A man will take risks handling 220 volts, and the conditions may be right for a fatality, but more precautions are taken with 440, and thus accidents are few.

This brings the power standard as 3 phase, 440 volts, 60 cycles. The lighting should be 110 volts.

There are two systems of installing wiring, namely, knob and tube, and conduit. The former is found in most of our mills, and consists of wires run exposed on porcelain insulators. The latter is a little more expensive to install, but is by far the better method. Ewa Plantation and Oahu Sugar Company are the only mills, to the writer's knowledge, that have all wire in conduit.

It must be confessed that the mill wiring work in Hawaii is far below standard. This may be due to the fact that electricity has played such a small part in the milling process, but the greatest fault lies in the fact that we have attempted, in many cases, to take a man from mill work and make him an electrician. Electricians should serve at least two years apprentice work under a good experienced electrician, thus becoming familiar with wiring, motors and electrical apparatus in general.

Wiring work should conform in every detail to the electrical code of the National Board of Fire Underwriters. This code explains how wiring should be installed. Copies will be sent gratis to any interested party by making application to the local board. It is published to protect the interest of the various insurance companies, but even though the plantation carries its own insurance, by following the code, they protect their own interests to the same degree that the insurance people are protected.

In laying out the wiring in a mill, provision should be made for at least six separate circuits from the switchboard in the mill. Each of these circuits should extend to a main distributing cabinet, and from these cabinets separate lines should be carried to the individual motors. At the switchboard, each circuit should be protected by an oil switch that would trip automatically when the circuit is overloaded. An ammeter should be provided on each circuit, showing the current taken by that circuit. In the distributing cabinet a separate fused switch should be installed on each line to the motor. This switch will allow breaking of the motor circuit, and the fuses will protect the main feeder should an excess load come on the individual motor line. Each motor should then be protected by a relay tripped switch. Motors $7\frac{1}{2}$ HP. and above of the squirrel cage type are furnished complete with this device. Motors below this size and motors of the wound rotor type can be provided with a relay-operated automatic oil switch. The above-mentioned relay is a magnet coil so wound that when the current taken by

the motor rises above a certain predetermined value, the magnet plunger operates a trip and throws the switch to the off position. It also has the feature of time element, which allows for momentary overloads without operating the trip. An ordinary fuse blows the moment the current exceeds its rating, then comes the cost of fuse replacements. The relay, after tripping, drops back into position and the motor is ready to start as soon as the cause of the overload has been removed.

The six circuits should be divided in the mill as follows:

Circuit No. 1—Mill circuit, controlling shredder motor, knife motors, unloader motors, raw juice pumps, bagasse coveyors, car haul.

Circuit No. 2—Boiling-house, controlling centrifugal motors, evaporator pump, juice pumps, conveyors, crystallizers, mixing tanks, washing machine.

Circuit No. 3—Pumps, controlling condenser pumps, water supply.

Circuit No. 4—Shop equipment, controlling blacksmith shop, carpenter shop, machine shop, ice plant.

Circuit No. 5—Lights, controlling all mill lights.

Circuit No. 6—Outgoing lines, controlling all power to outside pumps, camps, rock crusher, etc., and to return-power coming from outside source into the mill.

It is essential that the proper metering equipment be installed in order that each division of the plantation shall share its correct part of the manufacturing costs and line losses. Sketch No. 1 shows the most advisable method of metering. A watt hour meter records, on its dials, the total kilowatt hours consumed. The
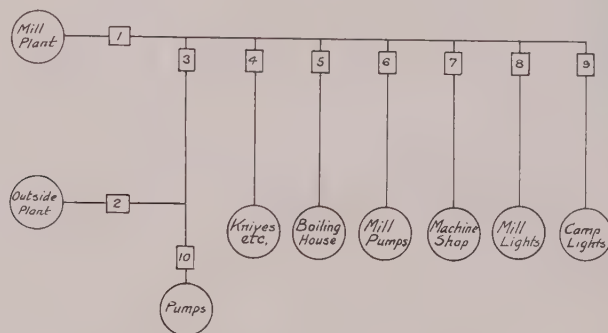
Sketch of wiring showing meter location.

mechanism is nothing more than a motor so designed that one revolution represents a certain amount of power passed through. This motion is transmitted through a train of gears and the kilowatt hours read directly from the meter. Refer to Sketch 1. There should be a watt hour meter at No. 1 giving the total output of the mill generators, another meter or meters No. 2 giving the output of all outside sources of power. The sum of these two will then give the total power generated. Meter No. 3 is used to determine the power sent into the mill from outside sources, and vice versa. Meters 4, 5, 6, 7, 8, 9 and 10 give the total power consumed in the various departments. The sum of readings 1 and 2 will be greater than 4, 5, 6, 7, 8, 9 and 10 by the amount equal to the line and transformer losses. These losses should be charged pro rata to the various depart-

ments. These losses will in some cases be as much as 15% of the generated power, especially where there is a large outside distribution system. The various departments within the mill should only share their proportion of the loss on the power delivered to it from the outside, for if the mill depended on its own generator, Meter No. 1 should equal the sum of the readings of 3, 4, 5, 6, 7, 8 and 9. The outside departments would then be charged as per reading on Meter No. 3, and their losses would be the difference between 3 and 10.

Each mill should be provided with proper portable testing equipment. If the motors are overloaded continually, they are liable to fail. A motor is designed to do so much work, and must not be abused. On the other hand, if a large motor is put on machines requiring only a small amount of power, the power factor is lowered, thus decreasing the capacity of the generating station. In order to determine what each motor or each feeder is doing, a test should be made once a year on the entire equipment. The following testing equipment should be available:

1 polyphase indicating wattmeter, 5/10 ampere, 150/300 volt scale.

2 portable current transformers capable of handling 1000 amperes and adjustable to several ratios.

2 portable potential transformers or multipliers. If the motors are 440 volts a 4:1 ratio is necessary. If motors are 220, these transformers are not needed.

1 5-ampere ammeter.

1 150/600-volt voltmeter.

The electrical industry has brought out several new devices in the past year, especially in lighting equipment. The new mill type Mazda is designed to be operated where there is severe jar or vibration. The new C-4 lamp is a gas-filled lamp enclosed in a white globe. This is only made in the 50-watt size. Radio telephony has been developed to a high state of perfection, and as soon as certain restrictions are removed, it will be possible to install small sending and receiving sets on the plantations, capable of direct communication with the Honolulu representatives.

We have yet unlimited possibilities in the use of electricity, and time only can show us what benefits can be derived.

The Loss in Sugar Between Field Cane Knives and the Mill.*

By E. T. WESTLY.

Most of us have always known that sugar is lost by delaying the milling of cane for any length of time after same is cut. But I feel sure none of us did realize the large amount that really is lost, as brought out by recent tests.

TEST I.

To determine the loss in sugar due to delays in milling cane after same is cut, 30 sticks of cane (Yellow Caledonia from Shimbori's place) was divided into 10 samples. One sample was ground the day the cane was cut. From then on, one sample was ground every day. The weight of the samples was also taken from day to day. Cane was cut on July 22, 1919.

| No. of Sample | WEIGHT (LBS.), JULY | | | | | | | | | | % Loss in Weight, Ground, Each Sample | Date Ground, July | JUICE | | | | Sugar per Original 100 Cane | Discarding the first analysis, and using 6.44 as average Q.R. of all samples when cut, we get the following losses in Sugar: | | |
	22	23	24	25	26	27	28	29	30	31			Brix.	Pol.	Pur.	Q.R.		Days Old	Per 100 Original Cane	%
1	17½										...	22	21.7	18.78	86.54	7.11	14.065	..	....	....
2	14¾	14¾									...	23	21.80	20.07	92.06	6.44	15.527	1	....	....
3	18	17¾	17¾								1.38	24	22.30	19.75	88.56	6.68	14.763	2	0.864	5.565
4	15¾	15¼	15¼	15							4.76	25	22.00	18.05	82.05	7.59	12.548	3	2.979	19.186
5	16¼	16	15½	15½	15¼						6.15	26	22.60	18.19	80.49	7.61	12.332	4	3.195	20.577
6	16¾	16¼	16	16	15¾	16					4.48	27	22.50	17.06	75.82	8.40	11.371	5	4.156	26.766
7	12½	12½	12¼	12	11¾	12	12				4.00	28	22.70	16.02	70.57	9.36	10.256	6	5.271	33.947
8	16¼	16	15¾	15¾	15½	15½	15¼	15¼			6.15	29	22.70	16.44	72.42	8.97	10.463	7	5.064	32.614
9	17	16¾	16½	16	15¾	16	15¾	15½	15¼		10.29	30	23.30	17.50	75.06	8.24	10.887	8	4.640	29.883
10	17½	17	16¾	16½	16¼	16½	16¼	16	15¾	15½	11.43	31	23.10	17.42	75.41	8.25	10.736	9	4.791	30.856
Av. % Loss in Weight		1.93	3.27	4.68	6.23	5.00	5.93	7.88	10.15	11.43										

REMARKS:—The analysis of the first sample looks like something was wrong. A check made on the analysis gave the same results. The sticks for all the samples came from a train at the scale. There is a possibility that the first sample contained one or more sticks of old cane picked up from the track and thrown onto the train. It seems also logical to assume that the original Quality Ratios of the different samples have varied to some extent when cut. Another test will be conducted.

Light showers of rain between July 26th and 28th.

TEST II.

YELLOW CALEDONIA CANE FROM FIELD NO. 11, CUT ON AUGUST 4, 1919.

40 sticks divided into 10 samples. Each sample divided into two by cutting each stick in two. Each sample contained two top and two bottom parts of the four sticks. One-half of all the original samples were ground and the juice analyzed the day the cane was cut.

No. of Sample	Date Ground, Aug.	ANALYSIS WHEN CUT					Weight When Cut, Lbs.	Date Ground, Aug.	Weight When Ground	% Loss in Weight	ANALYSIS WHEN GROUND					Loss in Sugar	% Loss in Sugar
		Brix	Pol.	Purity	Quality Ratio	Sugar per 100 Cane					Brix	Pol.	Purity	Quality Ratio	Sugar per Original 100 Cane		
1	4	20.60	18.51	89.85	7.073	14.138	18	5	18	....	20.5	18.18	88.68	7.245	13.803	0.335	2.369
2	4	21.20	19.10	90.09	6.846	14.607	18½	6	18	2.700	21.5	19.12	88.93	6.880	14.142	0.465	3.183
3	4	21.00	19.15	91.19	6.789	14.730	19¼	7	18½	3.896	21.8	18.98	87.06	7.002	13.725	1.005	6.823
4	4	20.50	18.47	90.10	7.078	14.128	18¾	8	18	4.000	21.9	18.02	82.28	7.590	12.648	1.480	10.476
5	4	20.90	18.91	90.48	6.901	14.491	16¼	9	15½	4.615	22.5	18.53	82.35	7.378	12.928	1.563	10.786
6	4	20.70	18.56	89.66	7.060	14.164	18½	10	17¼	6.757	22.2	17.78	80.09	7.806	11.945	2.219	15.666
7	4	21.10	19.17	90.85	6.794	14.719	17½	11	16½	5.714	21.9	16.15	73.74	9.025	10.447	4.272	29.024
8	4	20.50	18.06	88.10	7.316	13.669	17	12	15¾	7.353	22.1	17.90	80.99	7.707	12.599	1.070	7.828
9	4	21.20	19.24	90.75	6.773	14.764	17½	13	16¼	7.143	21.8	17.37	79.68	8.014	11.587	3.177	21.519
10	4	21.30	19.45	91.31	6.681	14.968	14¼	14	13	8.772	22.5	16.72	74.31	8.676	10.400	4.528	30.518

REMARKS:— The comparatively small loss in Sample No. 8 is hard to explain. This sample had the lowest Brix, Polarization, and Purity of all the original samples. It may be that the cane in this sample was not ripe at the time of cutting and that sugar kept on forming for a day or two after cutting, and that it did not start to go back before the second or third day. There is no doubt that the riper the cane when cut, the faster it will deteriorate. The conclusion may be drawn that in the beginning of the season, when less ripe cane is harvested, deterioration is much slower. In fact, the cane may at that time be benefited by being a day or two old before it is ground. Another interesting fact is brought out— that cane from the same field and within a very restricted area will differ considerably as to sugar content and purity. The above cane was all cut within a circle of 15 feet diameter.

The rainfall during the trial was as follows: August 4, 0.01 inch; August 5, 0.01 inch; August 6, 0.01 inch; August 7, 0.27 inch; August 8, 0.05 inch; August 9, none; August 10, 0.06 inch; August 11, 12, 13, none; August 14, 0.04 inch.

Samples were kept under field conditions.

Personally, I thought that cane two to three days old had not lost any mentionable amount of sugar. I feel different about it now.

There are several reasons why this loss has never been paid much attention. First of all the field and mill are entirely different departments, and one knows very little about what the other does. The field men are interested in getting the cane to the mill as easily and as cheaply as possible. They have very vague ideas about the chemical changes that take place in the cane after it is cut.

The mill men take it for granted that the cane is sent to the mill as fast as possible after it is cut. Most of the time they do not know if they are getting fresh or old cane. During the period a juice sample is taken (2-4-6 hours) both fresh and old cane may be ground. On account of this, very small difference may be shown between the different daily samples. At Paauhau we take a juice sample from the different fields every day as the cane is ground. Doing this I noticed that cane from a field would for a few days run, say, 8 quality ratio, then for a day or so go up to 9 or even more, and then come down again to 8. Other fields, again, would run very steadily. At other times all the fields would give poorer juices than usual for a day or so.

Inquiring into the cause leads me to believe that in most cases, when the juice went down, old cane was the cause. Before I go any further I would like to make the following statement: I sincerely believe that we here at Paauhau get the cane to the mill after it is cut as fast, if not faster than most Hawaiian plantations.

Far too little attention has been paid to the loss taking place between the field cane knife and the mill. The field men have been after bigger crops, and the mill men after extraction. It is bad business to grow cane and nurse it along for around 700 days, and then in a few days lose a good part of the sugar is contains.

To determine the losses we made a couple of tests. Thirty sticks of uniform Yellow Caledonia cane were taken from a train at the scale. This cane was known to have been cut a couple of hours previously. The 30 sticks were divided into ten samples of three each. One sample was ground right away, 24 hours later another sample was ground, and so on, with the results shown in Test I.

To avoid errors the sampling was modified. In this test the cane was cut and brought to the mill by the laboratory force. Forty sticks were cut in a field within a circle of 15 feet diameter, and divided into 10 samples. Each sample was then divided in two by cutting each stick in halves. Two top and two root sections were then taken from every sample. The 10 halves of the original 10 samples were ground on a hand mill and the juice analyzed immediately. The other 10 halves were weighed and spread out on the ground. Every day from then on one sample was taken in, weighed and ground. In this way the sample ground on, say, the fifth day was from exactly the same four sticks that were ground on the day the cane was cut.

From the above test and from tests conducted by the Experiment Station I have constructed the following three tables:

LOSS IN WEIGHT.

	D 1135	Lahaina	H 109	Y. C.
Fresh..................................	0	0	0	0
2 days old...........................	4.5%	4.6%	4.0%	2.7%
4 " "	8.1%	8.7%	7.4%	4.0%
6 " "	9.7%	12.5%	9.9%	6.8%

INCREASE IN TONS OF CANE REQUIRED TO MANUFACTURE ONE TON OF SUGAR.

(Figured from the different Q. R.)

	D 1135	Lahaina	H 109	Y. C.
Fresh..................................	0	0	0	0
2 days old...........................	.33	.07	.11	.03 *
4 " "	1.78	1.37	.43	.51
6 " "	3.11	3.48	.80	.75

* Decrease.

LOSS OF AVAILABLE SUGAR AS FOUND BY COMBINING THE WEIGHT LOSSES AND THE DECLINE IN QUALITY.

	D 1135	Lahaina	H 109	Y. C.
Fresh..................................	0	0	0	0
2 days old...........................	8.8%	5.7%	2.8%	3.2%
4 " "	27.0%	24.7%	12.2%	10.5%
6 " "	34.7%	41.4%	18.0%	15.7%

The losses given are really less than actual, as the same quality ratio formula that was used for fresh cane was also used for the old cane. It is obvious that the per cent fiber would go up as the cane dried out. If the actual per cent polarization of cane had been determined in all cases we would have got still higher losses.

It is not only the loss that takes place before the cane reaches the mill, but the work in the mill and boiling-house will be much poorer with old cane than it would be with fresh cane.

The above tables give the impression that Lahaina deteriorates faster than D 1135, D 1135 faster than H 109, and Yellow Caledonia slower than the rest.

But I am inclined to believe that it is not the difference in varieties so much as in the stage of ripeness of the cane when cut, and climatic conditions.

The purity of Lahaina when fresh was 92.50
"   "   " D 1135   "   "   " 91.30
"   "   " H 109   "   "   " 90.80
"   "   " Y. C.   "   "   " all the way from 89.7 to 91.20

Next season we intend to conduct tests on less ripe cane in the beginning of the season.

From the tests so far conducted it must be taken as an established fact that there are very big losses in sugar when old cane is sent to the mill.

I think it is up to all of us to look into this loss, as it is a loss that can be eliminated to a great extent without the expenditure of lots of money for expensive machinery.

I fully realize that all the cane all the time on a plantation can not be brought to the mill within 24 or even 48 hours after it is cut. But I believe that the per cent of 36 hours old cane and over can be considerably cut down. Places that run only single shift would be worse off than where the double shift is used. Irregular running should be avoided if cut cane is left over during the shut-downs. At times trains are side-tracked for one reason or another, and in that way stand around for considerable length of time. Ways and means should be found to determine how big a percentage of the cane is ground within 24 hours after it is cut, how much within 48 hours, and so on.

On a plantation where railroad transportation is employed one could send tickets along with each train, stating date A. M. or P. M. when the cane was cut. These tickets could then be taken off as the train passes the scale; date, time when ground added, and time elapsed figured out.

The Experiment Station claims that the Hawaiian sugar crop could be increased by 30,000 tons of sugar if the cans were ground one day sooner after it is cut than it is at present. In my opinion they have made a very conservative estimate. So let us go and get some of it.

Report of Committee on Methods.*

By Alex Brodie.

Walker's Proposed Procedure for Dry Lead Clarification.

At the annual meeting of the Hawaiian Chemists' Association, in October, 1917, Mr. H. S. Walker submitted, "for trial and criticism," a new method for the determination of sucrose in sugar-cane molasses. The procedure proposed by him is as follows:

Dissolve a double normal weight of molasses (52 gm.) in water and make up to 300 cc. Clarify in a larger flask with 15-20 gm. dry lead subacetate and a few grams of dry sand, and filter. To 75 cc. of the filtrate in a 100 cc. flask add

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20 cc. of a solution containing 100 gm. fosforic acid per liter, make up to 100 cc. with water, and filter. (The addition of half a gram or so of zinc dust just before filtration, while not usually necessary, lightens up the color of the solution perceptibly and has no effect on the polarization.) Reading in 400 mm. tube = Direct polarization. Take another 75 cc. portion of the original filtrate in a 100 cc. flask, add 2 cc. dilute HCl (1 volume concentrated acid to 1 volume water) to neutralize the alkalinity due to excess of lead subacetate, heat to 65°-70° C., add 10 cc. HCl (1 to 1), let stand in air 15 minutes or more, cool to room temperature, make up to 100 cc., add zinc dust in slight excess and filter. Reading in 400 mm. tube = Invert polarization. Sucrose = $\dfrac{\text{D-I}}{142.1 - 0.5t}$

This method differs from the dry lead method proposed by Cross and Taggart,[†] in that the direct reading is made in a solution made strongly acid with fosforic acid. The inversion is made by the method adopted by this Association in 1917.

COMPARISON OF THE PROPOSED METHOD WITH THE H. C. A. METHOD.

A number of molasses were analyzed by both methods, with the following results:

Sample I	Direct	Invert	t°C.	Sucrose	
				Observer A	Observer B
H. C. A.................	23.39	—14.61	25.6	29.41	....
D. L.....................	22.05	—14.96	26.4	28.71	28.61
Difference................				—0.70	....
Sample II					
H. C. A.................	22.06	—19.73	27.8	32.63	32.53
D. L.....................	20.72	—20.68	26.6	32.14	32.20
Difference................				—0.49	—0.33
Sample III					
H. C. A.................	25.24	—14.03	28.8	30.78	30.67
D. L.....................	23.96	—14.84	29.2	30.43	30.43
Difference................				—0.35	—0.24
Sample IV					
H. C. A.................	31.64	—16.24	29.	37.55	37.50
D. L.....................	31.52	—16.02	29.5	37.33	37.29
Difference................				—0.22	—0.21

In the proposed method, 500 cc. of solution was used; 30 gr. of dry lead gave a very good clarification, and is within the limits of the amounts proposed by Walker. The readings were made in 200 mm. tubes. In all other respects, the

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† Louisiana Bulletin No. 135.

details of the method as proposed were strictly adhered to. In all cases the dry lead method gave results 0.2 to 0.7 lower than those obtained by the H. C. A. method.

Comparison of the Proposed Method with the H. C. A. Method when Working on Known Mixtures.

In order to test this method with known mixtures, invert sugar was prepared. To a saturated solution containing 1500 gr. refined sugar, warmed to 60° C., 30 cc. sulfuric acid (1 to 1) was added; the mixture was allowed to stand, with occasional stirring, until the polarization became constant. The acidity was neutralized with an excess of calcium carbonate, and a trace of sodium carbonate; after filtering it was evaporated in vacuo to a thick syrup, which contained 9% water, 0.2% ash, and, from the polarization, 88.7% invert sugar. The refined sugar used to prepare this, and in the mixtures used, had a direct polarization 99.6, and a sucrose value 99.85.

Four solutions of lead precipitate impurities in molasses were prepared from time to time by the Pellet method, described by Mr. Walker.* To one kilogram of molasses, diluted to about 25 litres, was added 1000 cc. of subacetate of lead solution (54° Brix). The precipitate was washed by decantation until free from polarization; it was then decomposed by an excess of hydrogen sulfide. The lead sulfide was filtered off, and the filtrate evaporated in vacuo, at a temperature not exceeding 65° C., until a precipitate began to form.

The first of these solutions analyzed by the H. C. A. method showed:

Direct	Invert	"Sucrose"
—0.51	—0.60	0.07

50 cc. required 30 cc. subacetate of lead solution for precipitation. 86.67 gr. "impurities" and 26.615 gr. refined sugar were analyzed by the proposed method.

	Direct	Invert	t–C.	"Sucrose"
(1)...........	23.43	—9.43	26.4	30.15
(2)...........	23.62	—9.18	27.1	30.18
Average.....	....	.....	....	30.17

The sucrose actually present was $\dfrac{26.615 \times 99.85}{86.67} = 30.66$, so that the result was 0.49 too low.

71.5 gr. "impurities" and 22 gr. refined sugar by the H. C. A. method gave:

	Direct	Invert	t–C.	"Sucrose"
(1)...........	30.21	—9.33	27.8	30.87
(2)...........	30.32	—9.25	28.1	30.93
Average.....	....	....	...	30.90

* Record, Vol. XVII, p. 326.

The sucrose actually present was $\dfrac{22 \times 99.85}{71.5} = 30.72$, so that the result was 0.18 too high.

150 cc. impurities and 32 gr. refined sugar were analyzed by the proposed method, using the same amount of dry lead (30 gr.)

	Direct	Invert	t–C.	"Sucrose"
(1)............	35.58	—11.31	26.6	36.41
(2)............	35.76	—11.06	26.6	36.35
Average.....	....	......	...	36.38

The sucrose actually present was $\dfrac{32 \times 99.85}{86.67} = 36.87$, so that 0.49 too little was found.

100 cc. impurities and 26 gr. refined sugar by the H. C. A. method gave:

	Direct	Invert	t°C.	"Sucrose"
(1)............	35.83	—11.32	26.8	36.66
(2)............	36.16	—11.15	26.7	36.77
Average.....	....	......	...	36.72

The result obtained was 0.41 too high, as the sucrose present was 36.31.

Of a second solution of "impurities" 50 cc. required 15 cc. of subacetate solution for complete precipitation. A Clerget determination showed:

Direct	Invert	"Sucrose"
—0.37	—0.37	0.0

The following and all subsequent analyses by the dry lead method are based on 43.335 gr. samples, and those by the H. C. A. method on samples of 35.75 gr.

120 cc. "impurities" and 14.5 gr. refined sugar gave:

	Direct	Invert	t°C.	"Sucrose"
(1)............	32.73	—9.31	27.4	32.74
(2)............	....	.....	...	32.68
Average.....	....	.....	...	32.71

The sucrose present was $\dfrac{14.5 \times 99.85}{43.335} = 33.41$, so that the result obtained was 0.70 too low.

In this analysis an interruption prevented the direct reading from being made for approximately one hour, so a repetition was made. The direct polarization was made immediately, and also one hour and a half later.

	Immediate				After 1½ hours	
	Direct	Invert	t°C.	"Sucrose"	Direct	"Sucrose"
(1)..........	32.59	—9.56	27.9	32.89	32.15	32.55
(2)..........	32.28	—9.82	27.4	32.79	31.80	32.41
Average.....	....	.....	...	32.84	....	32.48

The following table shows the results obtained:

	"Sucrose"	Loss
Actually present	33.41	0.0
Found immediately	32.84	0.57
" after 1 hour...................	32.71	0.70
" " 1½ hour	32.48	0.93

When the direct reading was made very soon after adding the fosforic acid, there was found 0.57 less sucrose than was actually present; after a considerable delay the result was 0.70 too low, and still further delay increased the loss to 0.93, proving beyond doubt that some of the sucrose was being inverted.

To test this out, 50 gr. refined sugar was dissolved in water and made up to 250 cc. Four portions were pipetted into 100 cc. flasks, different quantities of fosforic acid added to three of them, and all made up to the mark. After mixing, these solutions were polarized immediately; solutions "a" and "b" were again polarized after 45 minutes.

No. of cc. 10% H_3PO_4 in 100 cc.		Polarization		Laboratory Temperature
		Immediate	After ¾ hr.	
a	0	38.35	38.47	28°—29° C.
b	2	37.90	37.60	28°—29° C.
c	5	37.32	....	28°—29° C.
d	10	36.85	....	28°—29° C.

The first polarizations of "c" and "d" showed so much inversion that these two solutions were at once discarded; but even 2 cc. of acid (in the absence of neutral salts) caused considerable inversion, and this increased greatly when the solution stood for 45 minutes.

A third solution of impurities contained 15% refractometer solids; of this, 10 cc. required 11 cc. subacetate solution for complete precipitation. It was analyzed by the H. C. A. method.

	Direct	Invert	t°C.	"Sucrose"
(1)...........	—0.16	—0.07	27.3	—0.07
(2)...........	—0.18	—0.09	26.9	—0.07

14.545 gr. refined sugar and 40 cc. impurities by the dry lead method gave:

	Direct	Invert	t°C.	''Sucrose''
(1)............	32.96	—9.65	26.9	33.12
(2)...........	32.78	—9.86	26.6	33.11
Average.....	....	.....	...	33.12

14.545 gr. refined sugar, 40 cc. "impurities" and 9 gr. invert sugar gave:

	Direct	Invert	t°C.	''Sucrose''
(1)...........	28.00	—14.62	27.5	33.21
(2)...........	28.06	—14.62	27.1	33.20
Average.....	....	.....	...	33.21

In both cases the sucrose present was 33.51. The results were 0.39 and 0.30 too low, showing that the invert sugar had very slight influence on the results. Similar mixtures were analyzed by the H. C. A. method.

12 gr. refined sugar and 33 cc. "impurities" gave:

	Direct	Invert	t°C.	''Sucrose''
(1)...........	33.65	— 9.88	27.	33.88
(2)...........	33.72	—10.03	26.7	34.01
Average.....	....	......	...	33.95

12 gr. refined sugar, 7.5 gr. invert sugar, and 33 cc. "impurities" gave:

	Direct	Invert	t°C.	''Sucrose''
(1)...........	28.66	—14.81	27.7	33.92
(2)...........	28.76	—14.80	27.3	33.94
Average.....	....	......	...	33.93

The sucrose present was 33.52, and here again the invert sugar had little effect on the results, which were 0.43 and 0.41 too high.

	Sucrose present	Sucrose found		Error	
		(1)	(2)	(1)	(2)
		Glucose present	Glucose absent		
D. L...........	33.51	33.12	33.21	—0.39	—0.30
H. C. A.......	33.52	33.95	33.93	+0.43	+0.41

The invert sugar solution (with "impurities") used above was analyzed for sucrose.

	Direct	Invert	t°C.	"Sucrose"
(1)............	—4.94	—5.01	27.2	0.06
(2)............	—4.92	—5.00	27.3	0.06

THE EFFECT OF REDUCING THE QUANTITY OF FOSFORIC ACID.

A fourth solution of "impurities" by the proposed dry lead method gave:

Direct	Invert	Sucrose
—0.1	—0.1	0.0

100 cc. of this solution represented roughly the impurities in a 43.335 gr. sample of molasses.

Two solutions were prepared, each containing 14.545 gr. refined sugar, 9 gr. invert sugar, and 100 cc. "impurities." After making up to 250 cc. each was clarified with 15 gr. dry lead, and filtered. For the direct reading, to 75 cc. of one filtrate 20 cc. 10% fosforic acid was added, and to 75 cc. of the other only 10 cc. of acid. The volumes were then completed to 100 cc. and the solutions filtered and polarized immediately. One hour later the tubes were again read. 75 cc. of each of the original solutions was inverted under exactly the same conditions.

	Immediate					After one hour		
	Direct	Invert	t°C.	"Sucrose"	Difference	Direct	"Sucrose"	Difference
(1)..........	28.67	—13.88	28.2	33.24	—0.27	28.09	32.73	—0.78
(2)..........	28.46	—14.08	28.0	33.21	—0.30	28.04	32.88	—0.63
Average...	....	....	...	33.23	—0.28	....	32.80	—0.71

10 cc. 10% Fosforic Acid.

	Direct	Invert	t°C.	"Sucrose"	Difference	Direct	"Sucrose"	Difference
(1)..........	28.78	—14.09	27.7	33.43	—0.08	28.74	33.40	—0.11
(2)..........	28.62	—14.26	27.6	33.42	—0.09	28.76	33.53	+0.02
Average...	....	....	...	33.43	—0.08	....	33.47	—0.04

We find that when 20 cc. of acid (in the absence of neutral salts) was used, inversion took place, causing a loss of 0.28% sucrose, which in one hour increased to 0.71%. On the other hand, when only 10 cc. of acid was added, the results were correct to well within the limits of experimental error. The dry lead used contained 1.4% moisture, so that 15 gr. would cause a dilution of 0.2 cc. This accounts for 0.02 to 0.03 of the loss noted. In all the analyses made by the dry lead method, about 0.5 gr. zinc dust was added to the solution before making to 100 cc. The resulting filtrates were light-colored, and very easy to read in the polariscope.

Conclusions.

In the hands of the writer the dry lead method, as proposed by Mr. Walker, gives results which are 0.3 to 0.5 too low when working with mixtures of which the sucrose content is known.

Should there be any delay in making the direct polarization, still lower results are obtained.

Much more fosforic acid is used than that required to precipitate the lead and restore the normal rotation of the levulose.

The excess of acid inverts a portion of the sucrose at laboratory temperatures above 27° C. Dr. R. S. Norris and the writer also found this to be the case when molasses solutions were deleaded with fosforic acid (2 cc. 10% H_3PO_4 in 100 cc.) in glucose determinations.*

When a small excess of acid is used the method gives very accurate results.

Comparative tests show that the results obtained by the H. C. A. method are 0.2 to 0.4 too high. In low-purity molasses, which give a very bulky precipitate with subacetate of lead, this error may be still greater.

In the presence of neutral salts (such as are in Hawaiian molasses), the large excess of fosforic acid may not produce inversion, but, to avoid any chance of this, the writer recommends that a smaller quantity be used.

When so modified your committee considers the proposed method to be preferable to that now in use, the advantages being:

(1) The error due to the volume of the lead precipitate is eliminated.

(2) The solution used for the direct polarization is light-colored, and easily read in a 200 mm. tube. (This is not always the case in the H. C. A. method.)

(3) The invert reading is made in ½ normal instead of ⅜ normal solution.

The above was the only method recommended to your committee for investigation. At the suggestion of Mr. W. R. McAllep, some work was done on another method.

The Determination of Sucrose in Cane Products by Direct Polarization, Using a New Method for the Destruction of Reducing Sugars.†

In 1916, Charles Muller proposed a method for determining the sucrose in cane sugar products by direct polarization after destroying the reducing sugars. Many such methods have been worked out, but apparently have failed to give accurate results except in the hands of the authors. Most of them, it appears to the writer, require as much, if not more, care than the method of double polarization. On account of its simplicity, Mr. McAllep suggested to your committee that Muller's method be investigated. The liquid used to destroy the reducing sugars is somewhat of the nature of Fehling's solution, and is prepared as follows:

Dissolve Rochelle salts 25 gr. and sodium hydroxide 32 gr. in 400 cc. distilled water by heating slightly; to this liquid add 11 gr. bismuth subnitrate. Continue heating until this is dissolved, cool, make up to 500 cc., mix and filter.

To apply the method to a cane-sugar molasses, Muller's instructions are:—
"20 gr. of the molasses are diluted with 40 cc. of boiling water. The liquid is

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* Record, Vol. XVII, p. 314.

placed in a 300 cc. flask, 15 cc. of the bismuth reagent added, and the mixture heated in a boiling-water bath for 15 minutes. The liquid is then cooled, 150 cc. of cold water and 60 cc. of basic lead acetate of 36° Bé. added, the volume completed to 300 cc., and the liquid mixed and filtered.

"This liquid is now polarized by introducing 100 cc. into a 100-110 cc. flask, adding 5 cc. of acetic acid, and sufficient water to reach the upper mark, treating with 2 gr. of special decolorizing carbon, mixing and filtering, the observation being made in the 400 mm. tube."

Muller claims that 15 cc. of the bismuth reagent are sufficient to destroy 3 gr. of reducing sugars, and that an excess of the reagent has no harmful effect. The above quantity is used for a molasses containing 15% reducing sugars. If the quantity of reducing sugars is believed to be more than this, he increases the amount of 1 cc. for each per cent above 15.

Mr. L. L. Lynch, of this Station, applied the method to several molasses which had been analyzed by the H. C. A. method. The per cent glucose in these was known, and sufficient bismuth reagent added to allow an excess of from 2 to 5 cc. No decolorizing carbon was used, and the polarizations made in 200 mm. tubes. In all other respects the operations were carried out exactly according to Muller's instructions. The polarizations given are the averages of the readings of three observers.

	Reducing Sugars	"Suerose"		Difference
		H. C. A. Method	Muller's Method	
1	10.2	39.29	28.00	—1.29
2	17.8	29.05	26.82	—2.23
3	20.3	34.75	33.51	—1.24
4	16.8	32.30	31.17	—1.13
5	14.2	29.89	27.43	—2.46

According to this method, the molasses contained from 1.13 to 2.46 less sucrose than was found by the H. C. A. method, which, however, has been shown by the writer to give results which are somewhat too high.

To see if there was any detectable destruction of sucrose, the bismuth reagent was tried on a solution of refined sugar, but no change in the polarization could be noticed. To see if the reducing sugars were completely destroyed, solutions of invert sugar were experimented with. In every case these gave a reading of about —1.0°, even when the heating was continued for twice the prescribed time.

It appears, therefore, that the invert sugar is not completely destroyed, and this accounts for the low results obtained by this method.